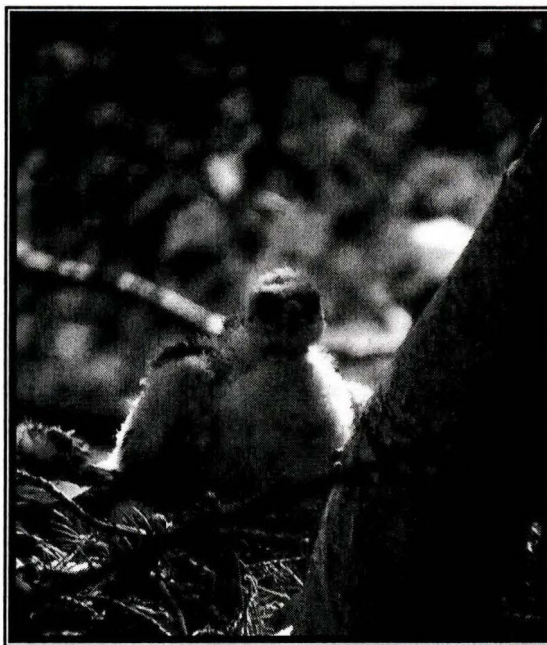


**NORTHERN GOSHAWK (ACCIPITER GENTILIS ATRICAPILLUS)
BREEDING STATUS IN THE SAN JUAN AND RIO GRANDE
NATIONAL FORESTS, SOUTHWESTERN COLORADO**

Northern Goshawk (*Accipiter gentilis atricapillus*)
Breeding Status in the
San Juan and Rio Grande *National Forests*, Southwestern Colorado



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26 January 2005

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Introduction

This report provides a summary of studies of northern goshawks (*Accipiter gentilis atricapillus*), hereafter referred to as goshawks, in the Rio Grande and San Juan National Forests, southwestern Colorado (Forest Service Region 2) during the 2002, 2003, and 2004 breeding seasons. It includes information on the breeding distribution, productivity, diet, and nesting habitat of goshawks on the two forests.

The goshawk is a "species of concern" throughout the western United States and is listed as "Sensitive" on the Rio Grande and San Juan National Forests. Concerns about potential effects of forest management on populations have emerged over the past three decades (Reynolds et al. 1982, Moore and Henny 1983, Reynolds 1983) to the point that the Federal government has been petitioned to list goshawks under the Endangered Species Act three times. Each petition to list has been rejected, in part due to lack of data (Kennedy 1997), yet goshawks remain the object of considerable litigation.

Goshawks have a Holarctic distribution (Johnsgard 1990) and are the largest of the three North American accipiters. In North America, their range extends from the boreal forests of Alaska and Canada, south to the montane forests of the west and northeast, and into the mountains of western and northwestern New Mexico (Squires and Reynolds 1997). Their breeding sites occur at elevations ranging from sea level to 3300 meters. They use a variety of forest cover types and structures for nesting and foraging and are considered a facultative mature forest structural stage species (Squires and Reynolds 1997; DeStephano 1998). They are sit-and-wait hunters, sub-canopy flyers, and a top level predator on a broad range of mammals and birds.

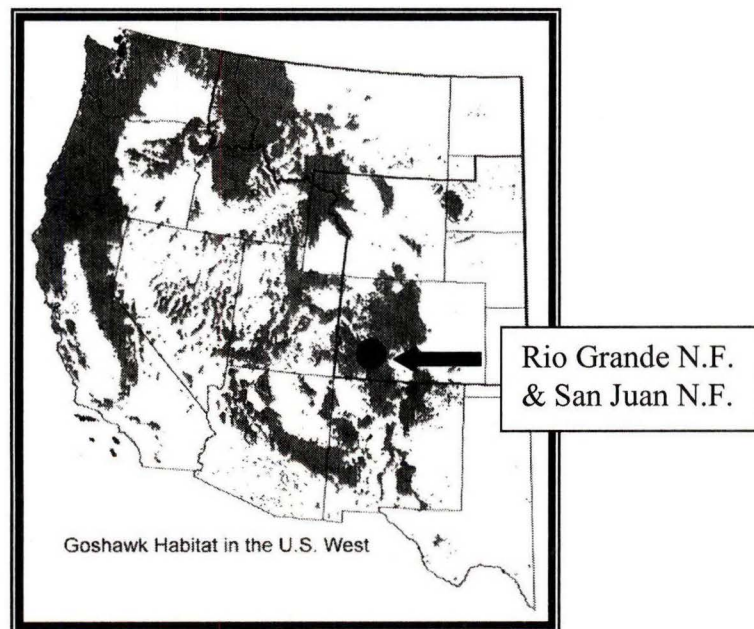
General goshawk nest site characteristics are described in this report. A complete habitat analysis, including a comparison of "available" habitat components at multiple spatial scales, is in progress, and scheduled for completion in the fall of 2005 (see C. Ferland's Masters Thesis, Oregon State University, Corvallis, Oregon).

This report is being distributed to each of the six Ranger Districts (Conejos Peak, Saguache, Divide, Pagosa Springs, Columbine, and Dolores) and two Supervisor's Offices (Rio Grande and San Juan), along with a CD containing the Rio Grande and San Juan National Forests Raptor Database.

San Juan Mountain Study Site Description

The San Juan and Rio Grande National Forests are immediately adjacent to each other on opposite sides of the Continental Divide in the Central Rocky Mountain Bioregion (Figure 1). The two forests encompass six ranger districts and approximately 19,600 km² (1,960,000 ha.), including the San Juan, La Garita, Cochetopa, and Sangre de Cristo Mountains. The area defined by these two national forests is hereafter referred to as the San Juan Mountains. Elevations range from 2,300 to 4,350 meters. The terrain is mountainous, and vegetation follows an elevational gradient from forb- and grass- dominated rangelands at the lowest elevations, to pinyon-juniper scrublands, to forests dominated by ponderosa pine (*Pinus ponderosa*), aspen (*Populus tremuloides*), mixed conifer, and Engelmann spruce (*Picea engelmanni*) – subalpine fir (*Abies lasiocarpa*). Mixed conifer forests contain an array of species including: Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), white fir (*Abies concolor*), bristlecone pine (*Pinus longaeva*), lodgepole pine (*Pinus contorta*), blue spruce (*Picea pungens*), Engelmann spruce, subalpine fir, and aspen.

Figure 1. Goshawk habitat in the western United States with reference to the Rio Grande and San Juan National Forests, Colorado



Nest Site Characteristics of Goshawk Territories in the San Juan Mountains

Goshawks are long-lived raptors (reports of 11 years in the wild) and have high nest site fidelity. Thus, once nesting territories have been established, they can be used intermittently for decades. Goshawks will construct from one to nine nests within a territory and often alternate nests inter-annually. Only one nesting pair will nest within a territory in any given year. Within a territory most alternate nests are grouped within a stand or cluster of adjacent stands and 80% of alternate nests will be located within an 1100-meter-radius area (Reynolds unpub. data). Goshawks typically place their nest in a sub-canopy position within a stand rather than on the edge of it.

Goshawks are a low-density raptor with cryptic habits and breeding sites can be difficult to locate initially. Nest sites are generally found by either systematic surveys or opportunistic nest/bird observations. The most common survey method for goshawks is the Broadcast Acoustical Survey (see Appendix B for a full description). This method takes advantage of the aggressive defense behavior of nesting goshawks, who will often vocalize and even attack intruders within their nest area.

Goshawk search and survey efforts in the San Juan Mountains over the past several decades have been inconsistent both temporally and spatially but there has been increasing effort and emphasis since 2002. The goshawk territories included in this report have been located by either broadcast acoustical surveys within random plots and project areas such as timber sales; or through follow-up searches at sites where goshawks/nests were reported. A total of 36 goshawk territories, known to have been used within the past 10 years; are distributed across the study area.

Throughout their North American range, goshawks nest in a variety of forest types including: Douglas-fir, ponderosa pine, aspen, mixed conifer-hardwood, beech, birch, etc. However, regardless of forest type, nest sites exhibit relatively uniform stand conditions including moderate slopes, mature structural stage forest conditions, high canopy cover, and open understories (Hennessy 1978, Reynolds et al. 1982, Moore and Henny 1983, Hayward and Escano 1989, Squires and Ruggiero 1996, Daw et al. 1998, McGrath et al. 2003). Although the absolute values for each site variable may differ among studies due to differing site ecologies, it is more important to recognize that these patterns are generally consistent and may be important for determining goshawk nest site potential.

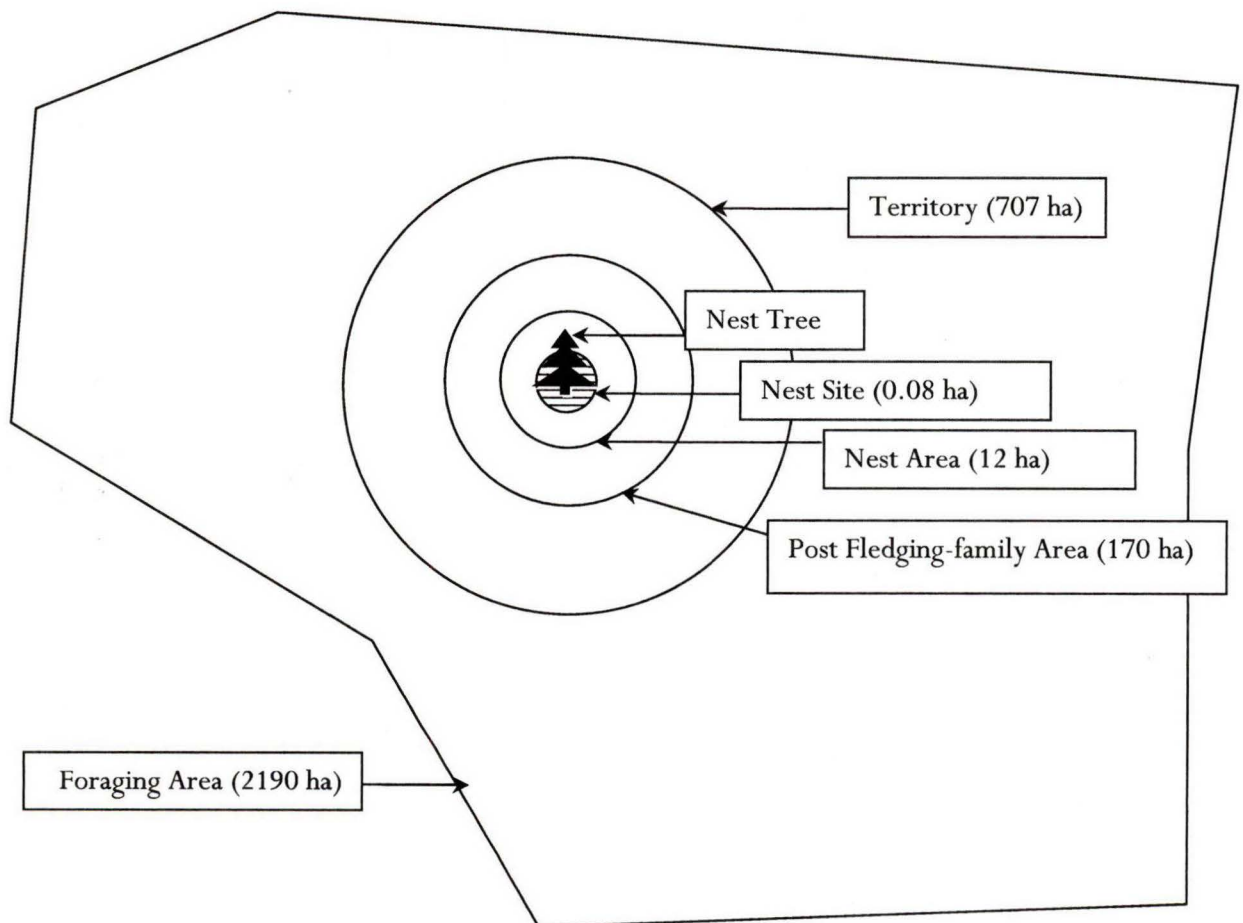
The Rio Grande and San Juan National Forests are adjacent to each other within the same ecoregion and greater mountain chain known as the Rocky Mountains regionally and the San Juan Mountains locally. Data in this report is summarized by National Forest not only because of administrative boundaries, but also because the range of forest conditions available to goshawks on each forest differs somewhat. For instance the San Juan National Forest contains a much larger proportion of ponderosa pine forest (23%) than the Rio Grande National Forest (3%) and elevations across the San Juan National Forest average almost 1000 meters lower than the Rio Grande National Forest. These are important factors to consider when evaluating the conditions in which goshawks are choosing to nest.

When evaluating habitat for goshawks, it's important to do so at a scale that's biologically meaningful. Reynolds et al. (1992) describes the components of a goshawk's nesting home range as being: the nest area (NA), post fledging-family area (PFA) and foraging area (FA). The size assigned to each of these components (30 ac/12 ha; 420 ac/170 ha; and 5,400 ac/2,190 ha; respectively) was based upon studies of goshawk activity during the nesting period. Two other important scales often used in habitat studies are the nest site (NS) and the territory. The nest site is the area immediately surrounding a nest (0.08 ha) and the territory is the general area surrounding a nest which is actively defended during the breeding season (707 ha). Exact goshawk territory size in the San Juan Mountains is undetermined but assumed to be similar to other studies. Hargis and Woodbridge (in press) compared the spacing of goshawk breeding sites (geometric centroid of all known alternate nests) in

three geographical areas and mean nearest-neighbor distances among goshawk nesting areas on the Kaibab Plateau of Arizona (Reynolds et al., in press), Southern Cascades Mountains (Woodbridge and Detrich 1994) and Modoc Plateau (Woodbridge unpub. data) were remarkably similar, ranging from 3 – 4 km. One-half of this distance, a radius of 1.5 – 2 km, yields an area of 707 – 1257 ha, which approximates territory size.

Goshawks are central-place foragers during the breeding season. Thus, areas of use smaller than the foraging area are roughly circular. The foraging area can take on a shape varying from circular to linear depending on topography and hunting habits of the individual goshawk. The biologically relevant spatial scales described above are depicted in Figure 2.

Figure 2. Depiction of the biologically important spatial scales surrounding a goshawk nest.



I assumed that minimum suitable habitat conditions required for goshawk nesting are any forested habitat, other than pinyon-juniper, containing poletimber-sized trees (12.7 cm DBH), or larger. Using this criteria, there are approximately 487,527 hectares of suitable forested habitat in the Rio Grande National Forest; comprising 48% of the overall National Forest ownership. There are 588,516 hectares of suitable forested habitat in the San Juan National Forest which make up 63% of the overall National Forest ownership.

In this study, nesting habitat was measured at the nest site scale (i.e. 0.08 ha). At each nest within all territories the following measurements were taken: nest tree diameter (DBH), nest tree height, nest stand structural stage, basal area, canopy cover, slope, aspect, elevation, and understory

condition. Nest tree diameter was measured in centimeters using a DBH-tape. Nest tree height was measured in meters using a clinometer. The structural stage of the stand was estimated based on the general size of trees and canopy cover. Basal area was measured with a 10 basal area factor prism using the nest tree as the center of the plot (readings were converted from square feet per acre to square meters per hectare). Percent canopy cover was averaged from 4 moosehorn measurements surrounding the nest tree. Percent slope was measured using a clinometer. Aspect was measured using a compass. Elevation was derived from a 1:24000 series topographic map. And the general condition of the understory was categorized as open, moderate, or dense depending on the presence and density of shrubs, seedlings and saplings.

As of 2004, 15 goshawk territories have been located within the Rio Grande National Forest (Figure 4). These territories are known to have been active within the past 10 years and comprise 40 nests/nest sites; averaging 2.67 nests per territory. Additionally, there are 3 historic territories and 3 potential territories. Historic territories are those that were last known active more than 10 years ago. Potential territories are those where nests and/or goshawk detections have occurred but never with enough evidence to eliminate the possibility that other species, such as red-tailed hawks, may have built the nests. There are 7 total nests/nest sites within the historic and potential territories.

In the Rio Grande National Forest goshawk nests occur at elevations from 2,719 meters to 3,306 meters, which is similar to the elevational range of suitable forested habitat. Ninety-five percent of the goshawk nests are in aspen trees and 5% are in Engelmann spruce (Figure 3). The forest type distribution of stands containing goshawk nests is: 73% aspen, 17% mixed conifer, and 10% spruce-fir (Figure 5). As depicted in Figure 5, based on available suitable forest types, goshawks are clearly selecting aspen nest stands in a much greater proportion than their availability, using mixed conifer in proportion to its availability and overall avoiding spruce-fir stands. These results could be confounded by the fact that it is much easier to spot goshawk nests within aspen forests than in spruce-fir forests. Likewise, prior to this study spruce-fir habitat was considered marginal for goshawks and subsequently little search effort was initiated in that stand type. However, the extreme difference in proportion of used stands (10%) compared to available stands (50%) is very likely true avoidance. It is also important to note that goshawks nesting within mixed conifer and spruce-fir stands select an aspen nest tree within those stands 73% of the time.

Figure 3. Goshawk nests in aspen forest type (left) and spruce-fir forest type (right), Rio Grande National Forest.

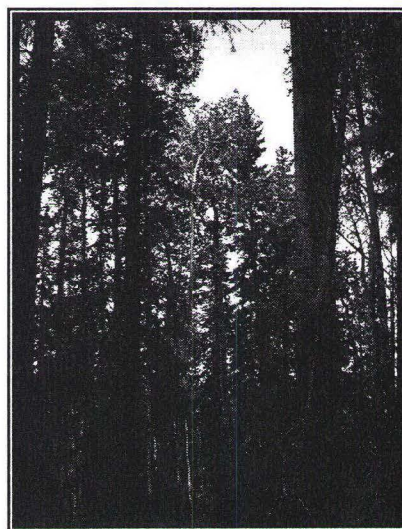
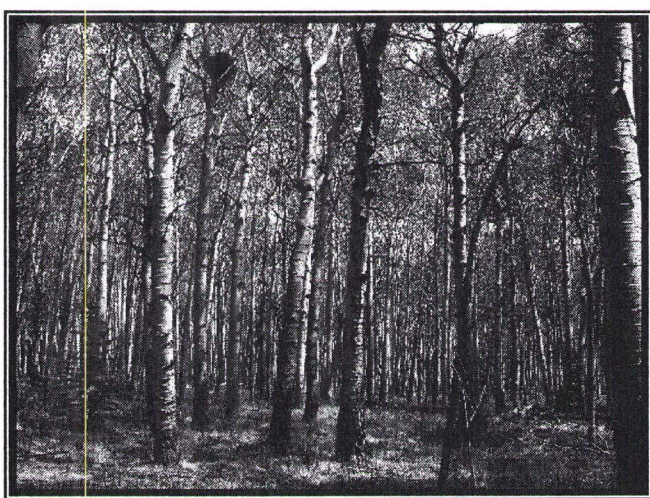


Figure 4. Northern goshawk nest territories in the Rio Grande National Forest

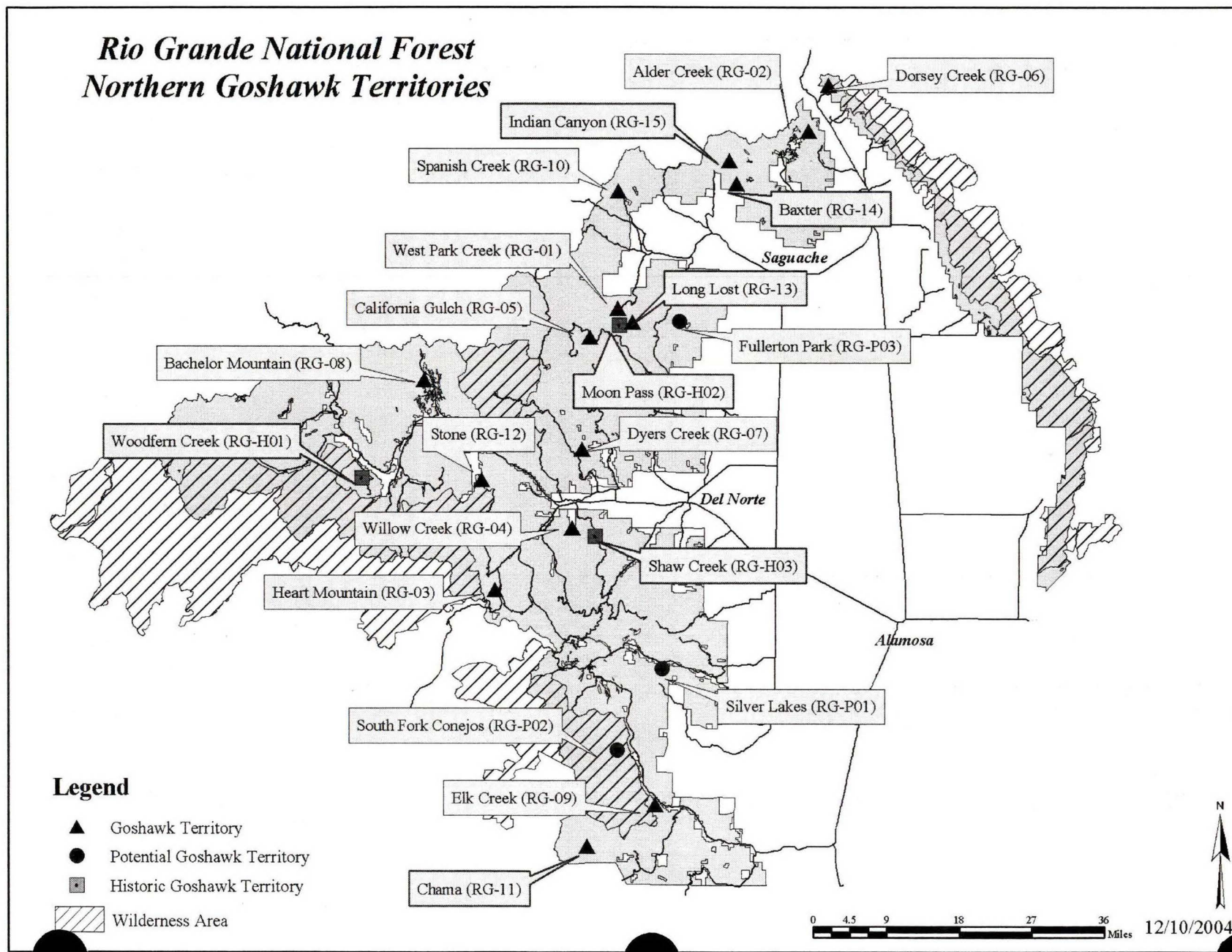
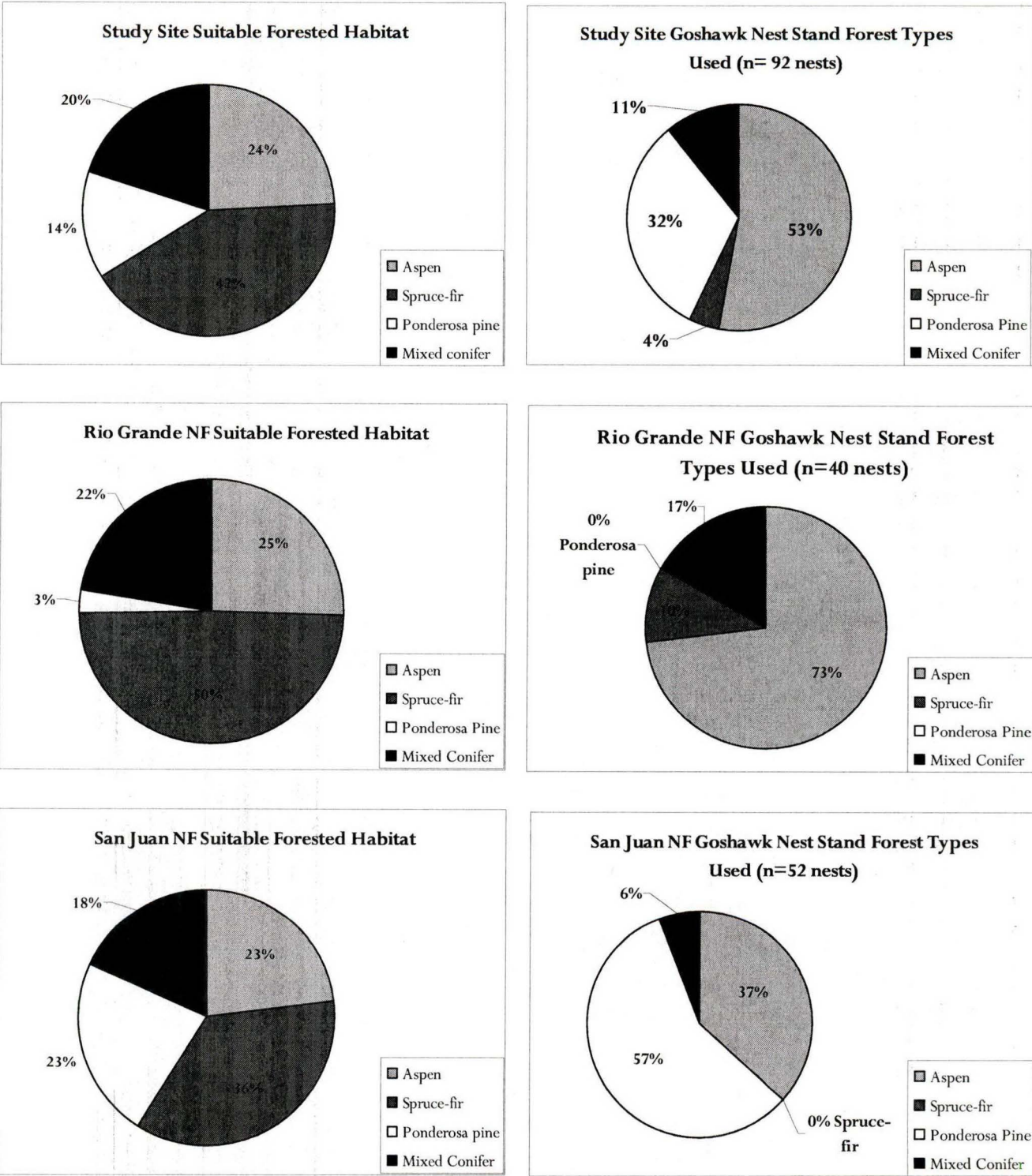


Figure 5. Range of suitable forested habitat types “available” (pie charts on left) compared to the forest types being used by goshawks for nesting (pie charts on right). Comparisons include the entire study site, and the individual national forests¹

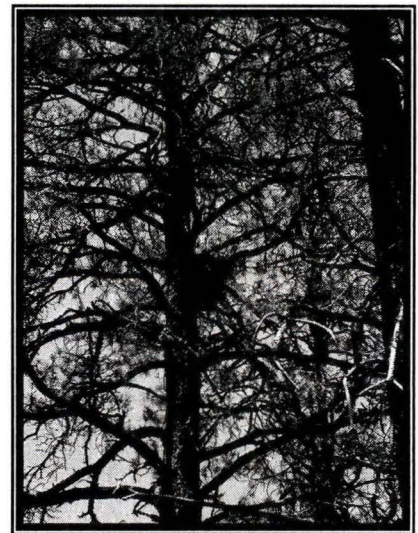
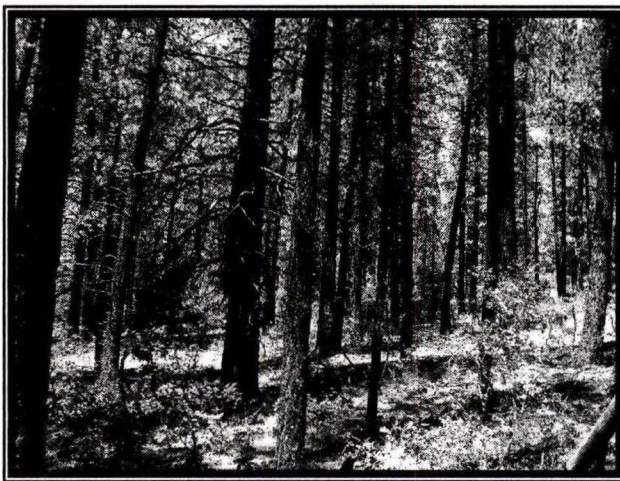


¹ Number of nests reported is a subset of overall nests due to incomplete field measures of habitat variables

As of 2004, 21 goshawk territories have been located in the San Juan National Forest (Figure 7). These territories are all known to have been active within the past 10 years and comprise 68 nests/nest sites; averaging 3.23 nests per territory. Additionally, there are 5 potential territories where nests and/or goshawk detections have occurred but never with enough evidence to eliminate the possibility that other species, such as red-tailed hawks, may have built the nests. There are a total of 6 nests/nest sites within the potential territories.

In the San Juan National Forest, goshawk nests occur at elevations from 2,121 meters to 2,987 meters which is similar to the elevational range of suitable forested habitat. Fifty-seven percent of goshawk nests are in ponderosa pine trees, 40% are in aspen trees, and 4% are in Douglas-fir trees. The forest type distribution of stands containing goshawk territories is: 57% ponderosa pine, 37% aspen, and 6% mixed conifer (Figure 6). As depicted in Figure 5, based on available suitable forest types, goshawks are clearly selecting ponderosa pine and aspen nest stands in much greater proportion than their availability, and avoiding mixed conifer and spruce-fir stands. Goshawks nesting within ponderosa pine and mixed conifer stands select an aspen nest tree within those stands only 6% of the time. In the San Juan National Forest, the selection of aspen nest trees within non-aspen stands occurs rarely as compared with the Rio Grande National Forest. This is probably correlated with the fact that across the study area, the proportion of aspen trees within non-aspen stands is generally higher (average 15%) in spruce-fir and mixed conifer forest types than it is in ponderosa pine forest types (average 7%), which tend to be monotypic, and are the dominant nesting forest type in the San Juan National Forest. Additionally, due to growth characteristics, ponderosa pine trees present more nesting opportunities than Engelmann spruce.

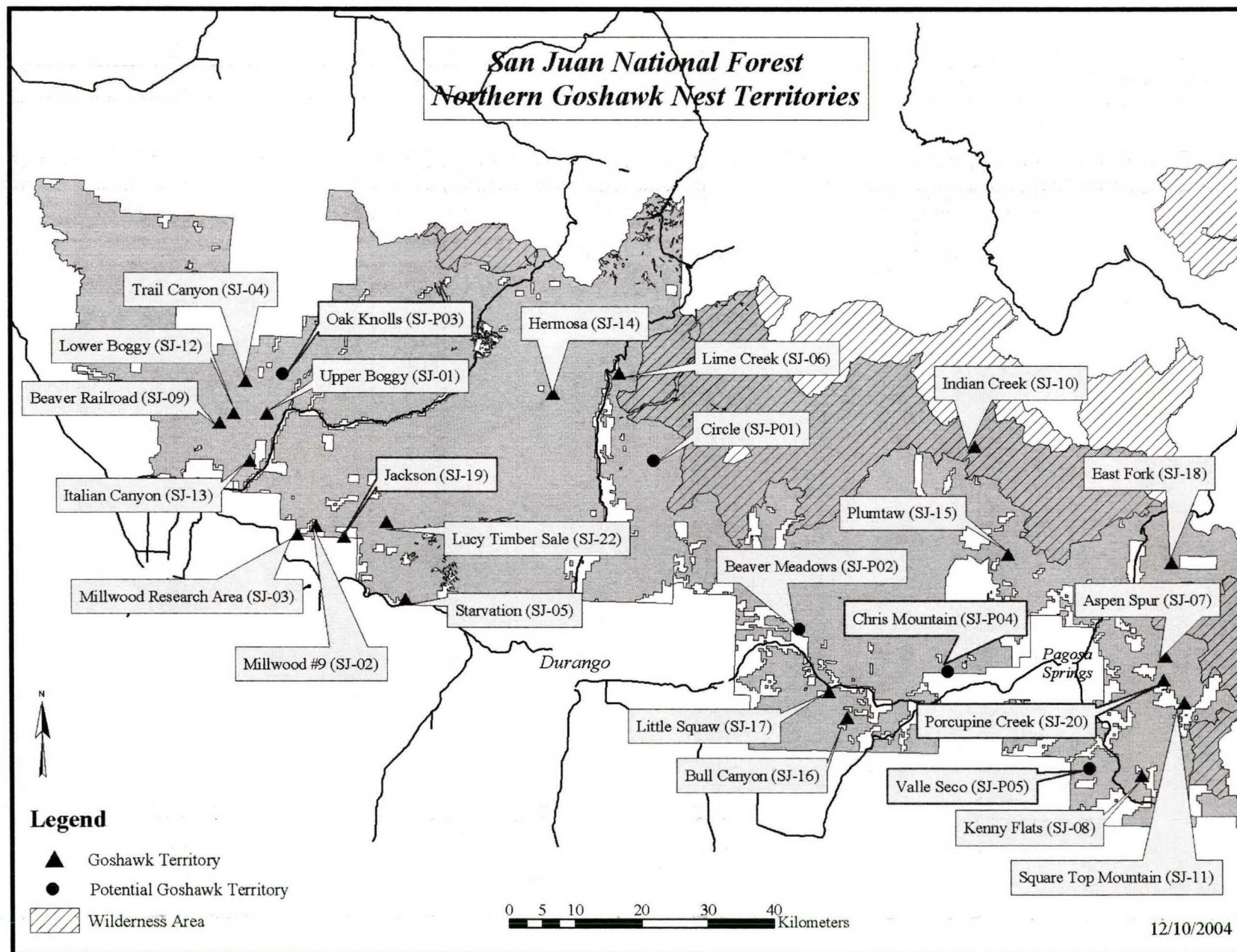
Figure 6. Goshawk nest site habitat (left) and goshawk nest (right) in ponderosa pine, San Juan National Forest.



In many other North American mid-latitude studies, goshawk nesting occurs on moderate slopes, with high canopy cover, and northerly and easterly aspects. Also goshawk breeding sites in other studies are often associated with mature structural stage forests (where those conditions are available) which have an open understory, uncluttered by dense saplings, seedlings, and shrubs.

All of the “classic” goshawk nest site habitat and landscape relationships apply to the San Juan Mountain goshawks. Most of the nest trees are located on sites with moderate slopes averaging 12% (range: 0-46%), with 82% of nests on slopes of 20% or less (Table 1). Note that

Figure 7. Northern goshawk nest territories in the San Juan National Forest



there is one nest on a 65% slope but it is considered an outlier. Canopy cover at goshawk nests is relatively high, averaging 67% across all sites, with 41% of nest trees located in areas with canopy cover greater than 70%, 48% of nest trees in areas with canopy cover between 41 and 70%, and only 11% of nest trees in areas with canopy cover of 40% or less (Table 1). Most studies report a site aspect regardless of slope at the site. However, slopes of 10% or less have such a slight gradient that there is little or no aspect effect at all. Thus, 54% of nest sites had no aspect effect, 35% are on northerly or easterly slopes and 11% are on southerly or westerly slopes. Only 4% of nest tree sites were found in poletimber-sized stands and the rest occurred in sawtimber-sized stands (i.e. mature structural stage forests) with relatively open understories, as would be expected.

Basal area of goshawk nest sites within hardwood stands (i.e. aspen) averaged 34 m²/ha or 148 ft²/ac (Table 1). Within conifer stands (i.e. mixed conifer, spruce-fir, and ponderosa pine), basal area averaged 35 m²/ha or 153 ft²/ac (Table 1). Hardwood nest tree heights ranged from 15 to 37 m (49 to 121 ft) and averaged 24 m (79 ft) (Table 1). And conifer nest tree heights ranged from 16 to 28 m (52 to 92 ft); averaging 22 m (72 ft) (Table 1). Average hardwood nest tree diameter was 38.4 cm (15.1 in), while nest tree diameters in conifer stands averaged 43.7 cm (17.2 in) (Table 1). There was one tree within the sample boasting a diameter of 135.1 cm (53.2 in) which was eliminated from the dataset as an obvious outlier. The tree is a double-trunked Doug-fir which forks above breast height, thus the diameter estimate is not representative of the fork in which the nest is located and would overestimate the mean if included.

Table 1. Goshawk nest site characteristics in the San Juan Mountains.

<i>Forest Type</i>	<i>Nests Reported #</i>	<i>Elevation m</i>	<i>Slope %</i>	<i>Canopy Cover %</i>	<i>Basal Area m²/ha</i>	<i>Nest Tree DBH cm</i>	<i>Nest Tree Height m</i>
All	93	2121 - 3306	$\bar{X} = 12$ (0 - 46)	$\bar{X} = 67$ (16-98)			
Hardwood	48				$\bar{X} = 34$ (14 - 55)	$\bar{X} = 38.4$ (24.3 - 66.5)	$\bar{X} = 24$ (15 - 37)
Conifer	45				$\bar{X} = 35$ (14 - 64)	$\bar{X} = 43.7$ (27.1 - 86.3)	$\bar{X} = 22$ (16 - 28)

There is very little comparative data regarding goshawk habitat associations in Colorado. Kennedy (2003) provides a detailed description of the status and habitat used by goshawks in the Rocky Mountain region (Forest Service Region 2). However, the goshawk occurrence and habitat use described for the San Juan Mountains in that report is very incomplete and thus not representative of the San Juan Mountain goshawks.

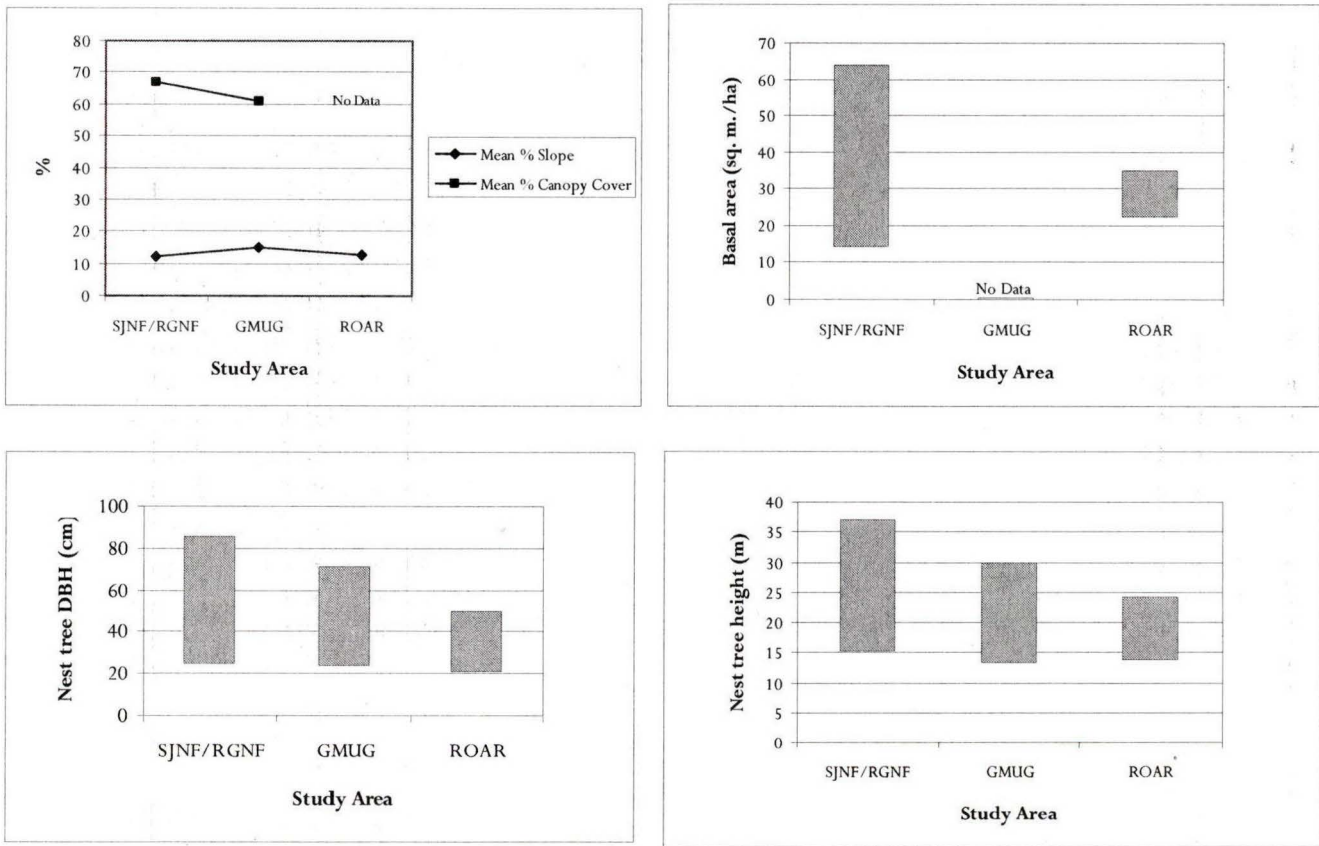
Shuster (1980) published data on 20 nests within the Arapahoe and Roosevelt National Forests and Rocky Mountain National Park (ROAR). Ten of those nests were in aspen trees, five were in lodgepole pine and five were in ponderosa pine trees. He found that basal areas of the nests ranged from 22 to 35 m²/ha., or 99 to 152 ft²/ac. and nest tree size ranged from 20.6 to 50.0 cm. DBH (8.1 to 19.7 in.) and 13.7 to 24.1 m. in height. Slopes at nest sites varied from 0 to 40% with a mean of 12.5%.

Land adjoining the Rio Grande National Forest to the northwest comprises the Grand Mesa, Uncompahgre, and Gunnison National Forest or GMUG. Le Fevre (2004) summarized data on 110 known goshawk nests/territories in the GMUG. Ninety-one percent of the nests are in aspen trees, 6% are in lodgepole pine and the remainder (i.e. 4 nests) are evenly divided into ponderosa pine and

Douglas-fir. Le Fevre (2004) found that nest trees within hardwood stands (i.e. aspen) ranged from 23 to 71 cm. DBH (9 to 28 in.). Diameter of nest trees within conifer stands (i.e. ponderosa pine, lodgepole pine, and Douglas-fir) ranged from 23 to 43 cm. (9 to 17 in.). Hardwood tree heights ranged from 13 to 30 m (44 to 97 ft.) and conifer tree height ranged from 15 to 21 m. (50 to 69 ft.). Canopy cover averaged 61% across all sites and slope averaged 15%.

Figure 8 provides a comparison of nest sites between the three Colorado studies. While there is a greater range of variation in the size of nest trees and basal areas in the RGNF/SJNF than in the other studies, this likely reflects the structural variation inherent within the individual forest types of each study site. Additionally, the Shuster (1980) study had a very small sample size. Mean slope and mean canopy cover of nest sites was very similar among studies.

Figure 8. Comparison of goshawk nest tree/nest site characteristics across three Colorado study sites. SJNF/RGNF = San Juan and Rio Grande National Forests (Data from this report); GMUG = Grand Mesa, Uncompahgre, and Gunnison National Forest (Data from Le Fevre 2004); ROAR = Roosevelt and Arapaho National Forest and Rocky Mountain National Park (Data from Shuster 1980).



We can interpret the vegetative and landscape characteristics used by nesting goshawks in relation to their ecology. Goshawks seem best adapted to nest site environments that allow a lot of sub-canopy flying room to accommodate their nearly one meter wingspan, and also to improve success in capturing prey. Thus, open understory conditions on flatter slopes are ideal. Goshawks build their own nests from sticks and the nests are quite large (1 meter across and 50 cm deep). Thus only large trees and/or trees with suitable nesting platforms such as large lateral limbs, forks, or mistletoe clumps will support a goshawk nest. Additionally, preferred sites should also maximize fitness of both adults and young by limiting pressure from predators, inter- and intra- specific competition, and perhaps provide

micro-climate advantages within the nest itself. A subcanopy nest position within a tree that is located in the interior of a stand, rather than on the edge helps address these needs.

It is also important to recognize that while the nest area is an area of concentrated use for goshawks during the breeding season (i.e. March through September), they will forage over a much larger landscape (approximately 2,200 ha.). Thus, conditions beyond the territory scale are influencing the birds as well. Additionally, they likely expand their home range even more during the winter months (October through February). San Juan Mountain goshawks have not been tracked over the winter so there is uncertainty regarding their winter movement patterns, however other studies at similar latitudes have found that most adult goshawks are partial, short-distance (<500 km) migrants. (R. Reynolds, USDA Forest Service, pers. comm.). Likewise there is no data on juvenile (natal) dispersal of goshawks in the San Juan Mountains. However, researchers are investigating the genetic structure of goshawk populations across the western United States through DNA sampling of goshawk feather molts. This may help answer questions regarding dispersal on a bioregional scale. Feather molts from San Juan Mountain goshawks were submitted for DNA analysis in 2003 and 2004. Results of the study will help elucidate the movements of goshawks at the scale of the western United States. Contact Shelley Bayard de Volo or Richard Reynolds at Colorado State University/USDA Forest Service, Rocky Mountain Research Station, for results of the study which should be available in 2006 or 2007.

San Juan Mountain Goshawk Nesting Chronology and Productivity

Understanding local nesting chronology is important for survey, monitoring, and management of goshawk nest sites/territories. Breeding goshawks center their activities around a nest/territory for typically 7 months out of a year. Courtship activity begins in early March and fledglings can remain in the nest area until the end of September.

Intensive nest monitoring was conducted on 2 active nests in 2003 and 11 active nests in 2004 to determine nesting chronology and productivity (Table 2). On average, four visits were made to each nest during the breeding season (March – September) in order to count and age young as well as to estimate dates of incubation, hatching, and fledging. Note that there are two active nests listed in the 2004 nests table (Table 2) – “Porcupine Creek” and “Long Lost” – which were found after nestling failure and fledging, respectively, and thus were not used to estimate productivity and chronology.

According to Squires and Reynolds (1997), courtship generally begins by 01 March, eggs are usually laid in late April or early May, and chronology may be delayed by cold, wet springs. Incubation generally lasts 28-32 days and the nestling period lasts from 35-42 days. Generally goshawks fledge within 40 days but this can vary by sex, and the fledglings often remain in the PFA for up to 8 weeks (Squires and Reynolds 1997).

The estimated dates of onset of incubation, hatching, and fledging reported here are based on a 30-day average incubation period. Nestling goshawks that were 28-days-old or older were assumed to have fledged. As Brian Woodbridge (pers. comm.) points out, this assumption is justified by the fact that accurate determination of the number of fledglings produced at goshawk nests is made difficult by the variability in fledging dates and behaviors of male and female fledglings. Male goshawks may leave the nest up to 10 days earlier than females, and fledglings may or may not return to the nest to roost and feed. Recently-fledged goshawks are often lost to predation, and are likely to be overlooked in fledgling counts. Simple counts of late-stage nestlings (28-34 days) have the potential to miss early-fledging males, or individuals laying down low in the nest cup, especially in larger broods. Thus, if productivity data are desired, it is preferable to use counts of large nestlings (24-30 days old) as a surrogate for actual number fledged.

Three of the eleven active nests that were intensively monitored in 2004 failed during incubation thus were not included in the estimates of nesting chronology. The cause of failure of these nests is unknown. Biologists climbed two of the three failed nest trees after abandonment. One nest contained 3 un-hatched eggs; the other nest contained no sign of eggs or chicks. Disturbance by goshawk observers is unlikely to have been a cause of failure since visits were of short duration (average of 15 minutes) and the female goshawks remained on their nests and only one out of the three even vocalized. Additionally, Squires and Reynolds (1997) report that disturbance associated with research has little impact on nesting birds. More likely causes for failure include: first-breeding-year females with limited experience; low prey availability; limited hunting success by male tasked with providing food to himself as well as the incubating female; and/or weather extremes such as high winds and/or rain which may have caused extreme thermodynamic stress on the incubating female and/or eggs/chicks. In fact, in 2004, there was an unusual number of days with localized high winds (> 15 mph) during late April and May in the San Juan Mountains. There was also greater rainfall and lower temperatures than usual during the incubation/early hatchling period in 2004.

The onset of incubation occurred almost two weeks earlier in 2004 than in 2003. In 2004, seven of the eight monitored nests began incubation between 26 April and 01 May (Table 2). One began a little later -- on 09 May. Conversely, in 2003, the two nests monitored began incubation on 13 May and 18 May (Table 2).

Figure 9 displays the range of dates for nesting chronology periods on the San Juan and Rio Grande National Forests in 2003 and 2004. These dates are likely to include representative dates for most breeding years within the study area.

Goshawk productivity was measured as the average number of fledglings per active and per successful nest. Goshawks typically produce only 1 clutch per year of 2 to 4 eggs. A nest was considered "successful" if nestlings were observed within 2 weeks of the normal fledging age of 42 days (i.e. > 28 days old). Nesting rates were much lower in 2003 than in 2004. The average number of fledglings per successful nest was 2.00 fledglings in 2003 when 6.7% of monitored territories were active; versus 2.44 fledglings in 2004 when 33% of monitored territories were active (Table 3). Squires and Reynolds (1997) report the number of young per successful clutch and pair is highly variable across North American goshawk studies but most populations produce from 2.0 to 2.8 fledglings per successful nest. However, measuring productivity based on successful nests alone can overestimate reproductive success, since it does not account for nests which failed prior to fledging. Comparing the number of fledglings per active nest reveals that reproductive success was actually higher in 2003 (average of 2.00 fledglings/active nest) than in 2004 (average of 1.55 fledglings/active nest), when 4 out of 11 nests failed (Table 3).

Nest success, or the percentage of nests which fledged young, was 100% in 2003 and only 64% in 2004 (Table 3). In other North American studies, nest success has been reported between 80% and 94% (Squires and Reynolds 1997). However, these studies involve much larger samples. The results reported in this study represent a very small sample size and should only serve as a rough estimate of productivity.

The 2003 breeding season was an extremely poor nesting year for goshawks in the southwestern United States. Active nests were found at only 2 of 30 (6.7%) goshawk territories in the San Juan and Rio Grande National Forests. Similarly low nesting rates were experienced in other parts of the southwest in 2003 (R.T. Reynolds, USDA Forest Service, pers. comm.). Annual variation in goshawk reproduction is associated with variation in prey and weather (Keane 1999) and 2003 was the fourth year of an extended drought in Colorado. Studies by Reynolds and Joy (1998) and Keane (1999) have illustrated a wide annual variation in reproduction. For instance, the proportion of territorial pairs with active nests varied from 22-86 % on the Kaibab Plateau in Arizona during the 1990s (Reynolds and Joy 1998). Thus, annual variation in reproductive activity is to be expected in the San Juan Mountains as well.

Table 2. Estimated dates of onset of incubation, hatching, and fledging in the Rio Grande and San Juan National Forests during the 2003 and 2004 goshawk breeding seasons.

["RGNF" = Rio Grande National Forest; "SJNF" = San Juan National Forest]

Goshawk Territory	Estimated Incubation Onset	Estimated Hatch Date	Estimated Fledge Date	No. Hatch	No. Fledge	Comments
2003 Breeding Season						
Alder Creek (RGNF)	18-May	17-Jun	28-Jul	2	2	On July 17th, there was fresh evidence of someone climbing the nest tree with a mechanical device. Suspect it had occurred within previous 24 hours. One fledgling was out of the nest and the other was capable of branching so suspect they escaped reach..
Indian Creek (SJNF)	13-May	12-Jun	22-Jul	2	2	
2004 Breeding Season						
Alder Creek (RGNF) ¹	26-Apr	26-May	5-Jul	2	2	This territory was also active in 2002.
California Gulch (RGNF) ¹	27-Apr	27-May	6-Jul	3	2	On July 18th there was evidence that the nest had been climbed (appeared to be a large cat) and there was one dead fledgling about 100 meters downhill from the nest. On July 23rd and Aug 12th there was one live fledgling in the nest area. This territory was also active in 2002.
Dorsey Creek (RGNF) ¹	30-Apr	30-May	Unk	1	Unk	There was one 16-day old chick seen on June 16th and only an empty nest on July 19th and July 27th so it's not certain if this chick survived and fledged.
Dyers Creek (RGNF)	Unk	N/A	N/A	N/A	N/A	Nest failed during incubation period. Witnessed incubation from May 3rd - June 9th but she had abandoned nest by the June 23rd visit. Climbed and retrieved 3 unhatched goshawk eggs
Long Lost (RGNF)	Unk	Unk	Unk	>=1	>=1	This nest/territory was discovered on 8/12/2004. The nest had successfully fledged at least one fledgling that was still in the area but there was no way to determine the nest chronology or productivity.
Stone (RGNF) ¹	1-May	31-May	Unk	3	3	There were three 30-day old chicks seen June 29th and only an empty nest on subsequent visits on July 23rd and August 10th so assume hatchlings fledged and dispersed or went undetected.
Willow Creek (RGNF)	Unk	N/A	N/A	N/A	N/A	Nest failed during incubation period (or early in nestling period). Witnessed incubation from April 28th - May 31st but she had abandoned nest by June 16th visit. Climbed into nest and could not find evidence of eggs or dead chicks.
Lime Creek (SJNF) ¹	9-May	8-Jun	18-Jul	4	4	Detected only 3 fledglings on last visit but all 4 were seen in the nest on a prior visit and were at least 28-days-old.
Millwood #9 (SJNF) ¹	27-Apr	27-May	6-Jul	2	2	None
Jackson (SJNF) ¹	25-Apr	25-May	4-Jul	2	2	None
Indian Creek (SJNF) ¹	28-Apr	28-May	Unk	2	2	There were two 28-30 day old chicks seen on June 25th but only an empty nest on July 25th. Assumed hatchlings fledged and dispersed early or went undetected.
Porcupine Creek (SJNF)	Unk	Unk	Unk	>=1	0	This nest/territory was discovered on June 24th. The nest had failed with no sign of adults and one dead, desiccated hatchling under the tree. The nestling's age of death was 14-17 days but there was no way to determine how long it had been dead.
Kenney Flats (SJNF)	Unk	N/A	N/A	N/A	N/A	Nest failed during incubation period. Witnessed incubation on May 28th but there was only an empty nest on June 24th visit.

¹ Active nests included in chronology/productivity estimates

Figure 9. Range of dates encompassing courtship, incubation, nestling, and post-fledging periods for northern goshawks in the San Juan Mountains, Colorado during the 2003 and 2004 breeding seasons.

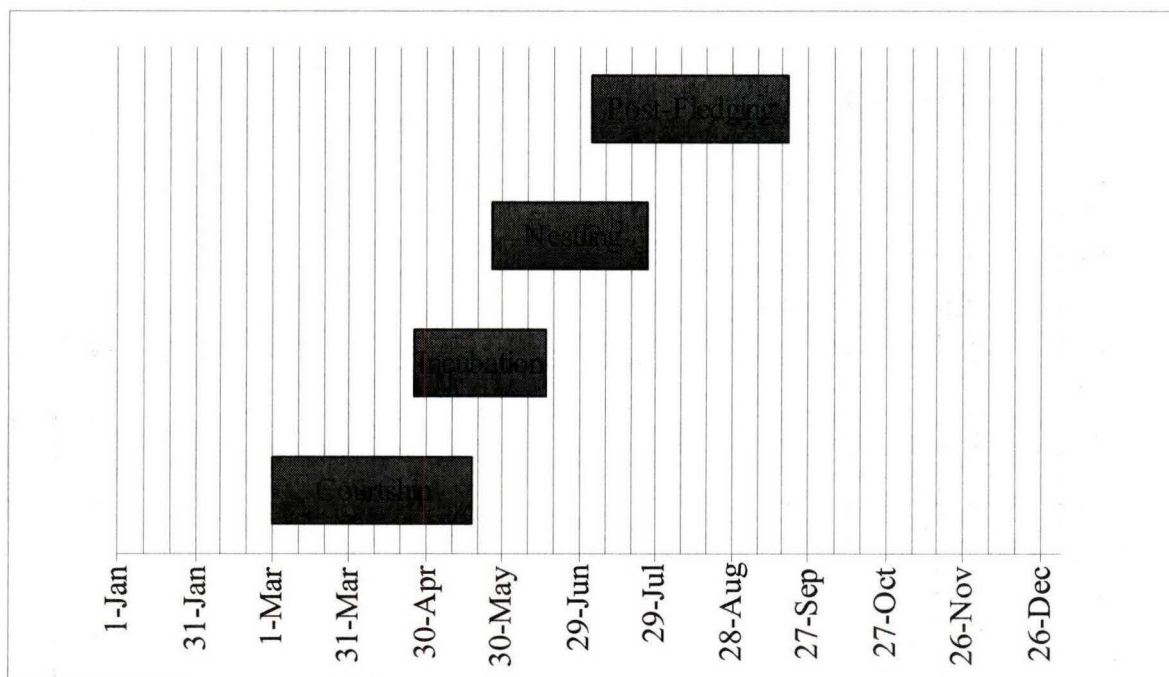


Table 3. Goshawk productivity and territory occupancy in the Rio Grande and San Juan National Forests for the 2003 and 2004 breeding seasons.

	No. Active Nests Monitored	No. Territories Checked	Nesting Rate (% active territories/ territories checked)	No. Fledglings	No. Successful Nests	Average No. Fledglings per Successful Nest	Average No. Fledglings per Active Nest	Nest Success (%)
2003								
<i>Rio Grande NF</i>	1	12		2	1	2.00	2.00	100
<i>San Juan NF</i>	1	18		2	1	2.00	2.00	100
Total	2	30	6.7	4	2	2.00	2.00	100
2004								
<i>Rio Grande NF</i>	6	17		7	3	2.33	1.12	50
<i>San Juan NF</i>	5	16		10	4	2.50	2.00	80
Total	11	33	33.3	17	7	2.43	1.55	64

San Juan Mountain Goshawk Diet

Prey items associated with goshawk nests were collected in 2002, 2003, and 2004 in order to determine at least a sample of the prey types consumed by goshawks in the San Juan Mountains. Prey remains were collected from underneath active nests, from plucking posts near active nests, and from castings (pellets) around active nests within 15 territories.

The species listed in Table 4 were verified as goshawk prey. The table is not inclusive of all prey items consumed by goshawks in the San Juan Mountains because prey remains were collected opportunistically. The list does however serve as a general menu of goshawk diets in the San Juan Mountains during the 2002, 2003, and 2004 breeding seasons.

Table 4. Prey species found in association with 15 different active goshawk nests in the San Juan and Rio Grande National Forests during the 2002, 2003, and 2004 breeding seasons.

Species	Common Name
<i>Ceryle alcyon</i>	Belted kingfisher
<i>Chordeiles mino</i>	Common nighthawk
<i>Colaptes auratus</i>	Northern flicker
<i>Cyanocitta stelleri</i>	Steller's jay (fledglings and adults)
<i>Dendragapus obscurus</i>	Blue grouse
<i>Nucifraga columbiana</i>	Clark's nutcracker (fledglings and adults)
<i>Perisoreus canadensis</i>	Gray jay (fledglings and adults)
<i>Pica hudsonia</i>	Black-billed magpie
<i>Sphyrapicus thyroideus</i>	Williamson's sapsucker
<i>Turdus migratorius</i>	American robin
<i>Zenaida macroura</i>	Mourning dove
	Robin-sized bird
<i>Lepus americanus</i>	Snowshoe hare (juveniles and adults)
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel
<i>Spermophilus variegates</i>	Rock squirrel
<i>Tamiasciurus hudsonicus</i>	Pine squirrel
<i>Thomomys spp.</i>	Pocket gopher
	Unknown rabbit
	Unknown beetle

Goshawks are generalist predators which forage over long distances, for relatively large-bodied birds and small to medium mammals. These prey items are typical of their diets. As Squires and Reynolds (1997) point out, goshawk prey species are extensive, but a few taxa are particularly prevalent. Dominant mammalian taxa reported across North America include: squirrels, rabbits, and hares. Dominant avian taxa include: grouse, corvids, woodpeckers, robins, and various passerines. One species which has not been documented as prey in prior published studies is the belted kingfisher. The kingfisher remains were found at a plucking post near an active nest that was located within ½-mile of a large lake.

2004 Goshawk Territory Monitoring in the San Juan Mountains

There are three basic ways to survey for goshawks: Dawn Acoustical (Courtship) Surveys, Broadcast Acoustical Surveys, and Intensive Searches. The methodology for each of these surveys is described in detail in Appendix B. Each survey type has a specific window of applicability. Dawn acoustical surveys can only be conducted during the courtship period (mid-February to late-March). Broadcast acoustical surveys and intensive searches can be conducted from June to late-August. And nest checks are ideally completed in May when most birds are incubating. Checking nests any later than May is likely to result in missing nest attempts that failed either during incubation or early hatching.

Dawn acoustical surveys involve 1-2 hour dawn sessions of listening and watching for goshawk courtship activities near known or suspected nest locations. Dawn acoustical surveys have a very high probability of detecting goshawks if present -- 90-100% (Penteriani 1999, Dewey et al. 2003). In addition, because surveys are conducted during early courtship, results are less affected by nest failure. They are also efficient because only 1-2 listening sessions are required to obtain detections (Dewey et al. 2003, Keane and Woodbridge unpub. data). The disadvantage of dawn acoustical surveys is that physical access is often challenging during late-February and March in the San Juan Mountains due to snow and/or mud. Seven dawn courtship surveys were completed in seven territories in 2004 (Table 5) and five of them were occupied by goshawks.

All nests and nest sites within 46 of the 47 known, potential, and historic goshawk territories were checked between May and late-August (Table 5). This resulted in visits to 121 nests/nest sites to determine their status (i.e. "active" or "inactive") and condition (i.e. "good", "fair", "partial/falling", "fallen", or "hijacked by squirrels"). Sixty-five percent of the nests were in "good" condition; 6% were "fair"; 9% were "partial/falling" nests; 16% "fell down"; and 4% had been "hijacked by squirrels".

Broadcast acoustical surveys entail projecting conspecific calls on a pre-determined grid within the survey area in order to elicit goshawk responses. In 2004, broadcast survey areas were delineated by a 600-meter-radius circle surrounding the geographic center of all nests within a territory. The average time to complete a 600-meter-radius territory broadcast was two days and 18 territories were surveyed this way in 2004.

A territory was considered "monitored" if it contained an active nest, a goshawk was observed, or a broadcast acoustical survey was conducted. This is a scaled down approach to measuring occupancy. Goshawks often change their nest locations within a territory inter-annually, thus nest checks alone are not sufficient for determining territory status. If the research intent is to measure occupancy trends over time, broadcast acoustical surveys should be completed within a 1600-meter radius of the territory and lack of detection would be followed by intensive searches within a 500-meter radius of each known nest within the territory. However, budgets and limited personnel did not accommodate this type of rigorous monitoring, thus, a smaller broadcast area was employed and intensive searches (as described in Appendix B) were not conducted at all. Monitoring results reported here should be kept in context with the methodology. In 2004, 33 out of 47 territories were "monitored" (70%). Of those, 39% contained active nests and a total of 55% were occupied (i.e. contained active nests and/or goshawks; Table 5).

Table 5. Goshawk surveys conducted in Rio Grande and San Juan National Forest territories in 2004

Goshawk Territory Code		Survey Type Conducted				2004 Status
RG=Rio Grande	SJ=San Juan	No. Nests/Nest Sites	Dawn Acoustical Survey	Nest Check	Broadcast Acoustical Survey ^a	
P=Potential; H=Historic	Territory Name					
RG-01	West Park Creek	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		n/a
RG-02	Alder Creek	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Active
RG-03	Heart Mountain	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-04	Willow Creek	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Active
RG-05	California Gulch	1		<input checked="" type="checkbox"/>		Active
RG-06	Dorsey Creek	8	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Active
RG-07	Dyers Creek	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Active
RG-08	Bachelor Mountain	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-09	Elk Creek	4		<input checked="" type="checkbox"/>		n/a
RG-10	Spanish Creek	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Occupied
RG-11	Chama	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-12	Stone	7		<input checked="" type="checkbox"/>		Active
RG-13	Long Lost	1		<input checked="" type="checkbox"/>		Active
RG-14	Baxter Creek	2		<input checked="" type="checkbox"/>		Occupied
RG-15	Indian Canyon	1		<input checked="" type="checkbox"/>		Occupied
RG-H01	Woodfern Creek	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-H02	Moon Pass	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-H03	Shaw Creek	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-P01	Silver Lakes	2		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-P02	South Fork Conejos	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
RG-P03	Fullerton Park	1		<input checked="" type="checkbox"/>		n/a
SJ-01	Upper Boggy	3		<input checked="" type="checkbox"/>		n/a
SJ-02	Millwood #9	2		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Active
SJ-03	Millwood Res. Area	4		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-04	Trail Canyon	7		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Occupied
SJ-05	Starvation	7		<input checked="" type="checkbox"/>		n/a
SJ-06	Lime Creek	2		<input checked="" type="checkbox"/>		Active
SJ-07	Aspen Spur	3		<input checked="" type="checkbox"/>		n/a
SJ-08	Kenney Flats	5		<input checked="" type="checkbox"/>		Active
SJ-09	Beaver Railroad	5		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-10	Indian Creek	2		<input checked="" type="checkbox"/>		Active
SJ-11	Square Top Mountain	2		<input checked="" type="checkbox"/>		n/a
SJ-12	Lower Boggy	6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-13	Italian Canyon	4		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-14	Hermosa	1		<input checked="" type="checkbox"/>		n/a
SJ-15	Plumtaw	1		<input checked="" type="checkbox"/>		n/a
SJ-16	Bull Canyon	2		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-17	Little Squaw	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-18	East Fork	2		<input checked="" type="checkbox"/>		n/a
SJ-19	Jackson	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Active
SJ-20	Porcupine Creek	1		<input checked="" type="checkbox"/>		Active
SJ-21	Lucy	6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Occupied
SJ-P01	Circle ^b	1				n/a
SJ-P02	Beaver Meadows	2		<input checked="" type="checkbox"/>		n/a
SJ-P03	Oak Knolls	1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Inactive
SJ-P04	Chris Mountain	1		<input checked="" type="checkbox"/>		n/a
SJ-P05	Valle Seco	1		<input checked="" type="checkbox"/>		n/a
Total		47 Territories	122	.		

^a 600-meter radius circle surveyed

^b Not visited due to 2003 Missionary Ridge Fire

San Juan Mountain Goshawk Population and Density Estimates

The entire study area comprises 19,600 km² of National Forest Lands. So far, 36 confirmed goshawk territories have been located as well as an additional 11 potential/historic territories. Goshawks are extremely territorial birds of prey and defend an area which can be described as a circle centered on the active nest (i.e. a territory). Density of breeding goshawk pairs is low overall and difficult to document because extensive nest searches are needed over large areas. As noted earlier, North American studies which have located the majority of nesting goshawks within their research area have found a relatively consistent nearest neighbor distance between territories. They have also noted that territories are often uniformly distributed.

Thus, to calculate a **very rough** estimate of the number of goshawk territories which could reside on the Rio Grande and San Juan National Forests, divide the suitable habitat by average goshawk territory size. There are 1,076,043 hectares of suitable habitat across the two forests. Assuming average goshawk territory size of 707 to 1,257 hectares, if all the suitable habitat were filled to capacity with adjacent goshawk territories, there would be from 856 to 1,521 territories. This estimate likely represents the very maximum amount of territories that could fit into the study area if suitable habitat were contiguous. Likewise, this estimate is not necessarily indicative of the number of pairs of goshawks residing in the study site. Most studies show that territory occupancy and/or nesting in any given year is highly variable; possibly in response to fluctuating prey densities and severe weather conditions. Actual goshawk pair density estimates reported in other western study sites range from 3.6 to 10.7 pairs per 100 km² (Squires and Reynolds 1997). Applying equivalent densities to the total suitable hectares present on the Rio Grande and San Juan National Forests yields from 387 to 1,151 total goshawk pairs. This estimate only takes into account the amount of suitable habitat which is not necessarily spatially distributed to correlate with density estimates presented in other studies. Population estimates over a large geographic area such as this are difficult to determine and **these figures represent only crude estimates**. However, I do think it is very conceivable that the San Juan Mountain study area contains at least 300 goshawk territories.

Limiting Factors and Threats to Goshawks

Typical factors limiting raptor populations include: predation, intra- and inter- specific competition, landscape alteration, nest site and food availability, pesticides/poisons, and disease (Newton 1979). Goshawks have relatively low reproductive rates, delayed maturity, and occur at low densities, thus are vulnerable to population impacts.

Likely predators of both young and adult San Juan goshawks include: golden eagles (*Aquila chrysaetos*), great-horned owls (*Bubo virginianus*), red-tailed hawks (*Buteo jamaicensis*) and mammals such as mountain lions (*Felis concolor*), Canada lynx (*Lynx canadensis*), bobcat (*Lynx rufus*), and pine martens (*Martes americana*). Also siblicide and cannibalism are known to occur, especially during periods of food deprivation (Squires and Reynolds 1997). There is very little published data on the extent of predation, but Kennedy (2003) does report on one study in which 49% of goshawk nestlings were predated by great-horned owls.

Harvesting of goshawks by falconers is an additional (predatory-like) pressure on goshawks in Colorado. As of 2004, the Colorado Department of Natural Resources (CDOW) allowed permitted falconers to harvest from one to three juvenile and/or passage goshawks annually (depending on the certification of the falconer). Falconers are only required to report the general location where goshawks are collected to the CDOW and this "take" information is often not communicated to appropriate USDA Forest Service biologists. At least one contact with a falconer seeking goshawks as well as evidence of someone (allegedly a falconer) climbing an active goshawk nest tree occurred in

the Rio Grande National Forest in 2003. Since the harvest of goshawks by falconers is very loosely regulated and monitored it is difficult to assess the impact to goshawks in the San Juan Mountains.

It is very likely that interspecific competition occurs between goshawks, great-horned owls, red-tailed hawks, and occasionally ravens, within the San Juan Mountains. Great-horned owls and red-tailed hawks are primarily forest-nesting species of similar body size and overlapping diet to that of goshawks. Ravens are not exclusive tree-nesters but are occasionally found using goshawk nests in the San Juan Mountains. Red-tailed hawks have been documented using nests originally built by goshawks as well. However, red-tailed hawks and great-horned owls are most commonly associated with more fragmented habitats than goshawks. A study conducted by La Sorte et al. (2004) in the Kaibab Plateau of northern Arizona confirmed this pattern. They compared habitat associations of sympatric red-tailed hawks and goshawks and found that red-tails were associated with non-forested areas located within 105 to 645 meters of nests sites while goshawks were consistently associated with patches of continuous forest and level terrain within 645 meters of nest sites. Red-tail nest sites were found on steeper slopes than goshawk sites, suggesting some level of nest site habitat partitioning between the two species.

Kennedy (2003) declares the primary threat to goshawk populations is alteration of preferred habitat from timber management practices. Forest fragmentation that occurs due to timber harvest can pose a direct threat by destroying nests and/or disturbing nesting birds and Bright-Smith and Mannan (1994) report that harvest methods that create large areas of reduced forest canopy cover (< 35-40%) may be especially detrimental. Kennedy (2003) states there is some evidence that goshawks are resilient to forest fragmentation and can re-establish when cleared areas are reforested; however the thresholds for population persistence have not been identified. Additionally, Squires and Reynolds (1997) conclude that forest harvest may be compatible with goshawk management provided that habitat needs are provided at multiple spatial scales. In California, nesting densities remained fairly high despite fragmentation of mature forests through timber harvest (Woodbridge and Detrich 1994); however territories associated with large contiguous forest patches were more consistently occupied compared to highly fragmented stands. The extent of forest management impacts to goshawks in the San Juan Mountains has not been evaluated.

As reported by Squires and Reynolds (1997), food availability is believed to strongly regulate goshawk populations by affecting population dynamics. There is a diversity of prey available to goshawks in the San Juan Mountains, but there is very little understanding of the abundance and distribution of that prey and its subsequent impact on the goshawk population.

From a habitat standpoint, nest site availability does not appear to be a limiting factor in the San Juan Mountains as there is an abundance of suitable habitat distributed across the study area. However, territorial spacing is thought to constrain the overall number of territories that any given landscape can support. In northern Arizona, Reich et al. (2004), found evidence to support their supposition that the availability of goshawk nesting sites was not limiting the nesting population on the study area. Instead, territoriality, and what appeared to be non-compressible territories, set the upper limit to the nesting population. And the ultimate choice of nest locations was probably constrained by the availability of high potential locations within spaces defined by neighboring territories. It is likely that the same conclusion could be drawn in the San Juan Mountains. Currently, however, there are not enough known goshawk nesting locations to validate this hypothesis.

The impact of pesticides on San Juan Mountain goshawks is unknown. The forested habitat supporting goshawks in the San Juan Mountains surrounds extensive agricultural areas where pesticides are in use. The amount of exposure of prey items to these pesticides is unknown. Many of the prey items consumed by goshawks during the breeding season are non-migratory, primary forest dwellers who spend little to no time within the agricultural areas. However, in the winter when prey is scarce and goshawks hunt at lower elevations, there is the potential to consume prey exposed to pesticides. The level of this risk and impact to goshawk populations has not been evaluated.

West Nile Virus is a disease potentially impacting goshawks in the San Juan Mountains. The disease has been documented occurring in birds which are residents in Colorado but there has been no testing of goshawks within the study area. The mosquito vectors of West Nile Virus are thought to be absent at high elevation so it is possible that San Juan Mountain goshawks have a low probability of exposure to this disease, at least on their breeding grounds, but further study is warranted.

Northern Goshawk Management Recommendations for the San Juan Mountains

Reynolds et al. (1992) developed management recommendations for nesting goshawks in the southwestern United States which present an approach to managing goshawks at a variety of spatial scales. This approach is recommended by Kennedy (2003) in the Region 2 goshawk conservation assessment for managing goshawk populations since it takes a landscape management approach. However, to date, most goshawk "management" in the Rio Grande National Forest has entailed only limited surveys in planned activity areas. When goshawks are located, small restricted activity buffer areas (from 100- to 500- meter radius) are placed around the active and inactive nests with seasonal disturbance restrictions -- usually from 01 March thru 31 July for active nests. Some districts conduct annual goshawk territory monitoring, including tracking occupancy and productivity, but this effort is inconsistent from district to district and year to year.

This type of goshawk "management" protects the nests and the immediate nest site from direct destruction and limits disturbance to actively nesting goshawks but it does not provide for the long-term viability of breeding goshawks. It does not account for the fact that goshawks often use alternate nest sites within a larger territory area (approx. 700 ha.), that they forage over a much larger area (approx. 2,200 ha.), and that their winter foraging needs often differ from their breeding season needs.

In the absence of a complete landscape management plan for goshawks within the Rio Grande and San Juan National Forests, it would seem reasonable to propose, at the least, a unified regional approach across the two national forests. The recommendations put forth in the 2000 Region 2 Northern Goshawk Strategy Team Status Report (Schultz et al. 2000) provide a good starting point. This approach is outlined below. It takes into account the entire territory rather than just protecting a small buffer area around known nests, with the goal of maintaining the structural integrity of the territory.

- Limit management activities in at least three known nest stands (approximately 12.1 ha each) or three replacement stands within historically active territories
- Management activities should not reduce the structural and compositional integrity of active and alternative nest stands.
- From March 1 – September 30, avoid timber harvest schedules that cause simultaneous, widespread disturbance across the goshawk fledgling habitat (PFA).
- Management treatments in the PFA associated with active and alternative nests should be designed to enhance prey species habitat, and structural and compositional diversity.

Additional recommendations per this report include:

- Monitor goshawk territories during the breeding season for occupancy and productivity. If it is not feasible to monitor all territories annually, then develop a sampling methodology to monitor a subset of territories over time.
- Gather additional data on San Juan Mountain goshawks' distribution, abundance, diet, threats/impacts from forest management, winter ecology, dispersal, migratory patterns, and habitat use through survey and research efforts.

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Appendix A: Glossary

Accipiters – the group of forest-adapted raptors. In North America there are three: northern goshawk, Cooper's hawk, and sharp-shinned hawk.

Active nest – goshawk nest with any of the following: incubating adult, nestlings/hatchlings present, or fresh green sprigs in combination with numerous feces, down, and prey remains.

Nesting chronology – sequence of dates entailing stages of nesting.

DBH – diameter at breast height (i.e. 1.4 meters or 4.5 feet).

Facultative mature forest structural stage species – a species preferring forests with mature structure (i.e. older forests with large trees) but not restricted to those conditions (i.e. not an obligate species).

Fledgling – in the case of goshawks, a hatchling that has left the nest via branching or flight.

Geometric centroid – the geographic center of a territory delineated by weighting all alternate nests by proportional years of use.

Holarctic distribution – a distribution that encompasses the Nearctic and Palearctic regions of the globe (i.e. all of North America, Mexico, and the West Indies, plus all of Europe, northern Asia south the Himalaya, and Africa north of the Sahara).

Nestling – a hatchling that is not yet capable of flight.

Nest site fidelity – faithfulness to a nest site.

Occupancy – a designation assigned to a goshawk territory containing either: an active goshawk nest, or presence of an adult goshawk confirmed by visual or aural detection and/or feather molts.

PFA – post fledging-family area extends approximately 0.57 km in radius (170 ha) beyond the nest area and is where fledglings spend the majority of time while still dependent on parents for food.

Plucking post – a location (often a stump or fallen log) where a goshawk plucks feathers or fur from their prey prior to consuming it. They often use the same plucking post repeatedly, especially one situated near a nest.

Appendix B: Goshawk Broadcast Survey Methodology

(Adapted from draft written by Brian Woodbridge, USFWS, 2003; Edited by Cheron Ferland, USFS 08 July 2004)

Aspects of Goshawk Natural History Related to Survey Methodology

At the geographic scale, goshawks reproduce in a broad range of vegetative communities, ranging from extensive mature coniferous forest in coastal regions to small patches of aspen and pine in Great Basin shrubsteppe communities. At the landscape or home range scale, goshawks utilize a diverse array of habitat, both in vegetation type and degree of openness (Squires and Reynolds 1997) for foraging. At the scale of nest-site selection, goshawks nest in the densest stands available, given the capability of the forest type, and therefore relatively high canopy closure appears to be a uniformly important habitat characteristic across the range of the species (Hayward and Escaño 1989). The size of forest patches used for nesting, and the degree of forest fragmentation within occupied landscapes appear to be highly variable across the species range. Numerous habitat studies and modeling efforts have found nest sites to be associated with similar factors including proximity to water or meadow habitat, forest openings, level terrain or 'benches' of gentle slope, northerly aspects, and patches of larger, denser trees, but these factors vary widely.

Where forest habitats are well-distributed, goshawk density is limited by territorial behavior, resulting in fairly regular spacing between the nests of breeding pairs. On the North Kaibab Plateau of Arizona, mean nearest-neighbor distance for 107 nesting pairs was 3.0 km (SD = 0.83) (Squires and Reynolds 1997). On the Klamath National Forest, the distance was a similar spacing of 3.3 km \pm 0.3 SE for 59 nesting pairs (Woodbridge and Detrich 1994) and similar spacing has been observed in other regions having long-term data, such as the Modoc National Forest (Woodbridge unpub.).

Within territories, goshawks typically make between-year movements among several alternate nests up to 1.12 miles apart (Woodbridge and Detrich 1993, Squires and Reynolds 1997). Although most alternate nests are grouped within a stand or cluster of adjacent stands, a search radius of 1200 yards is required to locate 80% of alternate nests used over a period of several years, and a search radius of 1.3 miles is required to locate 96% of alternate nests (Reynolds unpub. data).

Phenology of migratory movements, territory occupancy, and breeding exert an important influence on survey timing and methods. Goshawk populations in boreal regions, Great Basin, and portions of the Rocky Mountain region are at least partially migratory, whereas goshawks in Oregon, California and the Southwest may remain in the vicinity of their territories year-round (Squires and Reynolds 1997, Keane 1999, Richter and Callas unpub.). Adult goshawks typically return to nesting territories during March and early April (Squires and Reynolds 1997), and nest construction commences soon thereafter. Eggs are usually laid in mid-April to early May. Incubation lasts about 30 days, resulting in hatching dates during mid-May through early June. Nestlings remain in the nest for 36-42 days, typically fledging in late June through late July. Newly-fledged goshawks remain close to the nest tree for 2-3 weeks, then begin making longer movements until dispersal in mid-late August (Kennedy et al. 1994, Squires and Reynolds 1997).

Although notorious for their aggressive defense of nest sites, breeding goshawks are typically secretive and nest sites are often difficult to locate. At specific times, goshawks can be quite vocal in the vicinity of active nests, and this characteristic enables the use of taped vocalizations for locating them. However, goshawks do not 'sing', so surveyors cannot depend on stereotyped behavioral responses to territorial calls – a technique used successfully to census owls. For goshawks, broadcast calling methods are dependent on eliciting defensive responses from adults, or food-begging response from fledglings or the adult female. Compared with territorial song responses, these responses are much more variable and are highly dependent on reproductive chronology and status.

Direct visual and auditory detectability of goshawks varies during the reproductive cycle. Prior to egg-laying, detectability is high due to courtship vocalizations and over-canopy flights. However, during incubation and the early nestling period adult females are often unresponsive and detectability is very low. Defensive behavior by adult goshawks increases during the nestling and fledgling periods, resulting in increased detectability. As the fledglings reach 2-3 weeks of age, they begin to respond to broadcast of food-begging calls and this accounts for the majority of detections late in the season (July – August) (Keane and Woodbridge 2000).

Survey methods are also dependent on indirect detection of goshawks through 'sign'; old nest structures, molted feathers, feces, and remains of prey. Abundance of sign tends to increase steadily throughout the breeding season, and may be detected at territories occupied by nonbreeding goshawks.

Female goshawks begin molting primaries and secondaries during incubation; males molt later in the summer (Henny et al. 1985). This results in scattered feathers visible on the ground in the immediate vicinity of active nests or roost areas beginning in May and increasing through the breeding season. Detection of multiple feathers from an adult female goshawk is strongly indicative of an active nest site nearby. Molted feathers of male goshawks tend to be more widely scattered.

Goshawks forcefully eject their feces, resulting in long white streaks ("whitewash") on the forest floor and downed trees near favored perch sites and active nests. While these deposits are not reliably diagnostic of occupancy by goshawks, they do indicate regular presence of a large raptor and areas deserving focused searches. During incubation, female goshawks defecate from perch sites away from the nest; detectable accumulations of whitewash do not occur at the nest until the nestlings are about 10 days old and begin defecating over the nest edge (typically late May – early June).

Remains of prey items are another important source of 'sign' used in goshawk surveys. Goshawks frequently pluck or dismantle their prey on exposed sites such as downed logs, stumps, or snags, leaving patches of feathers and fur. These sites, known as 'plucking posts', may be scattered throughout the territory, but a few typically occur near nest areas, often upslope from the nest or in an adjacent opening. Detection of patches of feather or fur pulled from medium- to large-sized prey species such as squirrels, hares, grouse, woodpeckers, and jays is highly suggestive of goshawk presence, and areas deserving focused surveys.

During courtship and early nest-building, goshawks may add fresh material to multiple nests before settling on a single nest for the breeding effort. Dawn courtship vocalizations may occur at these 'extra' nests, although the active nest may be hundreds of yards distant. Detection of nests 'built-up' with new sticks and green sprigs, in combination with other sign such as molted feathers and whitewash, indicates an occupied territory. Such nests are frequently misclassified as abandoned or failed nests during survey and monitoring efforts.

Largely silent outside of the breeding season, goshawks become quite vocal during courtship and nesting. There are at least four distinct vocalizations that may be detected during goshawk surveys:

Alarm call: a harsh *kak-kak-kak* repeated many times, typically directed towards intruders near the nest, but occasionally used between pair members.

Wail call: a loud, plaintive, drawn-out call used in communication between pair members. During nesting, female goshawks often wail from the nest, possibly a form of food begging.

Food begging call: a thin, plaintive wail given by nestling and fledgling goshawks to solicit food delivery or express hunger.

Food delivery call: a short, guttural '*kuk*', usually given singly or widely spaced, given by the male goshawk upon entering the nest area with prey. This call typically elicits wailing and frantic begging from the female goshawk and older nestlings, and from fledglings during the post-fledging dependency period.

The ability of any particular survey method to determine occupancy or reproductive status is affected by the probability that a territory is occupied or by the probability of a territory having an active or successful nest. Work conducted to date indicates that northern goshawks exhibit high degrees of annual variation in reproduction (Reynolds and Joy 1998, Keane 1999). Less work has been conducted on determining annual variation in territory occupancy (although we do know that some territories may be unoccupied for one or more years), largely because determining occupancy in territories without successful nests requires intensive and extensive surveys early in the breeding period and adult goshawks on territories without successful nests are difficult to detect. Representative data from the Sierra Nevada and Kaibab plateau indicate the magnitude of annual variation observed (Table 1) (Reynolds and Joy 1998, Keane 1999). The proportion of territorial pairs with active nests varied from 22-86% on the Kaibab Plateau in Arizona during the 1990s (Reynolds and Joy 1998). Annual variation in reproduction is associated with variation in prey and weather (Keane 1999).

Table 1. Variation in territory occupancy, nest activity, and nest success for northern goshawks observed in the Lake Tahoe Region, California, and Kaibab Plateau, Arizona during 1992-1996.

Variable	Lake Tahoe Region				Kaibab Plateau				
	1992	1993	1994	1995	1992	1993	1994	1995	1996
No. Territories	17	17	19	24	37	64	82	88	100
% Occupied ¹	100	82.4	84.2	87.5	95.3	89.0	38.6	75	64.5
% Active Nests	100	76.5	47.4	70.8	86.5	76.6	22.0	48.9	39.0
% Successful Nests ²	82.4	47.1	36.8	58.3	59	62.5	15.8	37.5	29

¹ percent of territories meeting criteria for 'confirmed occupancy'

² percent of all occupied territories fledging at least one young.

The implications of the results presented in Table 1 for survey efforts are that annual variation in reproduction will likely have large effects on the effectiveness of surveys. For example, only 37% and 16% of the monitored territories had successful nests in 1994. If the survey design relied solely on broadcast surveys conducted during the nestling and fledgling periods, such survey efforts could have very low probabilities of locating territories and/or determining occupancy and reproductive status because response rates of non-breeding territorial adult goshawks, or pairs with failed nests, is unknown and probably lower and more variable than at territories with successful nests. When considered along with the probability of detection associated with a particular survey technique, and along with the effects of observer variation, annual variation in reproduction can have large effects on the effectiveness of northern goshawk survey efforts.

During courtship and nestbuilding, goshawks are highly susceptible to human disturbance, and have been recorded to abandon nest areas following human intrusion. Incubating females often appear to be unmoved by human intrusion near their nest, but may interrupt incubation for extended periods to defend the nest. Surveys involving physical entry into potential nesting habitat should not be conducted until late May-June. Early confirmation of occupancy should be determined by Dawn Acoustical Surveys or rapid visual checks of known nests from a distance, but no earlier than May 15.

Basic Survey Methods

This section describes four basic protocols for conducting surveys for northern goshawks. The relative advantages and disadvantages of each method are dependant on the objectives of a given survey. Dawn Acoustical surveys and Intensive Search surveys are time- and labor- intensive methods with high detection rates – they are most appropriate for surveys focused on known goshawk sites and patches of high-quality habitat. Broadcast Acoustical surveys, on the other hand, are better suited for covering large areas efficiently. These protocols may be used singly or in combination to achieve a variety of objectives.

Dawn Acoustical Survey

This method is based on detection of courtship vocalizations and flight displays of goshawks at their nest sites. It consists of establishing “listening stations” in close proximity to known nest stands or patches of suitable habitat, and conducting 1.5-hour listening periods at dawn during the early breeding season (Penteriani 1999, Dewey and Kennedy *in press*).

1) Establishment of Survey Stations: Listening stations should be positioned within 150 meters of all habitat to be surveyed. Use aerial photographs to determine point location providing optimal coverage of suitable habitat within 150 m radius (7.1 ha.). To reduce attenuation of sound by surrounding vegetation or landforms, locate stations on slightly elevated position whenever possible, but not on ridges or in large openings. Efficiency may be increased by location of stations on roads; however there may be tradeoffs with position within habitat patches. Stations must be clearly marked to allow their location in darkness.

Whenever possible, establish multiple stations approximately 300m apart to achieve simultaneous coverage of entire survey area by multiple observers.

2) Timing of Surveys:

Seasonal timing - To coincide with the peak of courtship vocalizations by goshawks at their nest sites, surveys should be conducted during the 1½ months preceding egg-laying. Reproductive chronology likely varies between geographic regions and elevations, and local information should be used to estimate egg-laying dates. Back-dating from estimated ages of nestlings can be used to determine reproductive chronology; use Boal (1994) to estimate ages of nestlings, add 33 days incubation period. For example, if nestlings are typically 15 days old on June 15, surveys should be conducted in your area between March 15 and April 28. Note that during years with particularly cold or wet spring weather, onset of incubation may be delayed for up to 1 month.

If there are no detections of goshawks during the first listening session, a repeat session should be conducted prior to May 1. Two sessions are required to assign ‘unoccupied status’ to the area surveyed.

Session timing – Observer should arrive and be settled at listening station *at least* 45 minutes before sunrise. Listening session should continue until 1.5 hour after sunrise. Plan carefully so that the entire listening session can be conducted without interruptions for moving position, warming, eating, potty breaks, etc.

3) Listening Session Methods: During each listening session, record start and stop time, actual sunrise onset, time and duration of goshawk vocalizations, type of goshawk vocalizations, direction (bring compass) and estimated distance of goshawk vocalizations.

Dewey and Kennedy (*in press*) reported a variety of calls detected during dawn acoustical surveys in Utah. Calls included variations of the alarm call (*kak kak kak*) (Squires and Reynolds 1997) and plaintive wail call (Squires and Reynolds 1997). Length of vocalizations varied from short 1-note call segments to series of alarm calls and wails lasting up to 10 seconds.

4) Locating Nest Sites: Auditory detection of goshawks during courtship indicates occupancy of a particular forest patch; subsequent location of the nest should not be attempted until after the estimated date of hatching. **Intensive Stand Searches** should be employed to locate nests.

5) Observer Training: The principal requirement of this method is familiarity with vocalizations of goshawks and other species likely to be detected during surveys. Taped examples of goshawk alarm and wail calls, as well as vocalizations of

pileated woodpecker, northern flicker, sapsuckers, and Cooper's hawk should be memorized and reviewed prior to conducting surveys.

An important aspect of Dawn Acoustical Surveys is observer transportation during early spring when snow conditions may limit access to many survey areas. Safety and logistical feasibility are important concerns when considering use of snowmobiles and skis before sunrise, often in rugged terrain. However, prior experience with forest carnivore, great gray owl, and goshawk surveys has shown that safe, efficient access is possible under these conditions, particularly if multiple observers are employed to provide assistance. Training in snowmobile use, winter travel safety, and communications are essential for employment of this method.

Primary advantages of this method are that surveys can be conducted early (February-April), about 2-4 months before Broadcast Surveys can be initiated, and that surveys have a *very* high probability of detecting goshawks if present (Penteriani 1999, Dewey and Kennedy *in press.*). In addition, because surveys are conducted during early courtship, results are less affected by nest failure. Only 1-2 listening sessions are required to obtain detections (Dewey and Kennedy *in press.*, Keane and Woodbridge *unpub.*).

Penteriani (1999) reported detection rates of 100% at occupied goshawk nests in hardwood forests of southern France. Validation studies by Dewey and Kennedy (*in press.*) demonstrated a 90% detection rate at listening points <150 meters from 20 occupied goshawk nests during March and April in conifer/conifer-aspen forests in Utah. Goshawks were detected during Dawn Acoustical Surveys at 19 of 20 (95%) occupied nest stands in northern California (Keane and Woodbridge *unpub.*). Six of the occupied sites contained nonbreeding pairs.

Primary disadvantages of this method are: 1) that it may be logistically difficult to apply in areas where access is limited by snow during the period when surveys would be conducted (however, prior success with forest carnivore surveys suggest that use of snowmobiles and skis need not represent an obstacle); and 2) listening points survey a limited area (150 meter radius), therefore many stations may be required to cover large areas such as timber sales. If only 1 year of survey is used, this method may not identify nest stands that are unoccupied during the year of survey. Only one station (7.1 ha.) can be surveyed per observer per day.

Intensive Search Protocol

This method combines visual searches for signs of goshawk occupancy (nests, whitewash, prey remains, molted feathers) along closely-spaced (20-30 meters) transects (Reynolds 1982), with broadcast acoustical surveys. Goshawk calls are broadcast along within-stand transects simultaneously while visual searches are taking place. This method is best applied to smaller units of area (10-100 acres), following stratification of habitat quality (Reynolds 1982, Keane and Woodbridge 2000).

1) Establish transect routes and coverage: Use aerial photographs and transportation maps to determine placement and direction of transects for optimal coverage of habitat to be surveyed. Determine compass bearing to be used in each survey. Number of observers (and simultaneous transects) is determined by size of habitat patch or unit to be surveyed; typically a minimum of three observers is required. Attempt to 'anchor' start and end points of transects on roads, trails, streams or other features.

2) Timing of surveys: Stand searches require presence of multiple observers within nesting habitat and are likely to cause excessive disturbance to breeding goshawks if conducted too early in the nesting period. Do not initiate surveys prior to estimated hatching date.

The effectiveness of stand searches increases as the nesting season progresses, as nestling goshawks become more vocal and whitewash, molted adult feathers and other sign accumulate in the vicinity of the nest. Stand searches are most effective during late June, July and August. Stand searches may be conducted until snowfall; however, detections will be increasingly dependent on sign as adult and young goshawks move out of the nest area in the fall, and sign is lost due to rainfall and leaf fall.

3) Number of surveys: If conducted by experienced observers during late June, July or August, a single stand search may be sufficient to determine occupancy status of a habitat patch. However, if *any* sign of presence of goshawks (feathers, old nests) is detected during searches, repeated surveys are necessary to determine nest core location (unless occupied territory status is assumed).

Data from Keane and Woodbridge (*unpub.*) indicate that single-visit detection rates obtained with this method are about 97% at goshawk sites with active nests, 73% at sites with occupied-nonbreeding status, and 43% at unoccupied historical nest stands (table 2). If survey objectives require detection of sites with nonbreeding adults, then two visits are required to achieve detection rates greater than 90%.

4) Equipment needed: Broadcast system, ziploc baggies and labels, flagging, compass, reference feather collection

5) Conducting Stand Searches: Following a pre-determined compass bearing, observers should walk parallel transects spaced 20-30 meters apart (30m spacing may be used in open, tall-canopied stands where visibility is high). Mark the start point of each transect point with individually-marked flagging to allow retracing of survey. Middle of 3 observers should broadcast recorded goshawk vocalizations at points every 250 meters along the transect, on every 3rd transect line (all observers follow procedure 3 under Broadcast Acoustical Survey). Attempt to maintain 250 x 250 meter spacing of broadcast stations.

Searches should be conducted at a leisurely pace, allowing ample time for scanning the ground for sign, logs and low limbs for plucking sites, and *all* trees for nest structures. Any sign encountered (feathers, prey remains) should be collected in ziploc bags labeled by transect location. Visual or auditory detections of goshawks should be recorded by transect location and detection type. Careful attention to location of adjacent observers, especially the middle (broadcasting) observer, and compass bearing are important to maintain consistent spacing of individual transects.

At the end of each individual transect, each observer should stop, flag the transect end point, and move to the start point of the next transect. If transects are directed back into the same habitat patch, the 'hinge' or end observer should space the new transect no more than 20 meters from the previous transect; this reduces the potential of unsurveyed strips of habitat between transect groups.

6) Post-survey activity: Following completion of a survey, observer notes, data forms, and collections should be immediately reviewed. Any feathers collected should be identified by comparison with reference samples. Prey remains should be identified and their frequency of occurrence assessed for each transect area. Any reports of whitewash and prey remains should be mapped, based on transect location notes. The entire area actually surveyed should be mapped.

Although whitewash and/or prey remains may indicate occupancy by other predator species, whitewash *and* remains of typical goshawk prey (e.g., snowshoe hare, grouse, Douglas squirrel, Stellers jay, northern flicker) are suggestive of goshawk presence, and trigger "possible occupied status" and follow-up survey of the suitable habitat surrounding (min. 300 meter radius) the site. This is particularly true if the initial survey was conducted early in the season, prior to July.

Because female goshawks molt during incubation and nest attendance, their molted flight feathers are typically found in the immediate vicinity of occupied nests. To allow determination of feather source, reference feather collections should contain examples of male and female flight feathers. Male goshawks molt later in the season, and their feathers may be found over a larger area. Detection of goshawk feathers triggers "occupied status" and follow-up surveys of the suitable habitat surrounding the site (min. 300 meter radius) to locate the active nest.

If visual or auditory detection of a goshawk is made during an Intensive Search, *and* sign is present in the stand surveyed, the area should be considered occupied. To locate the nest, follow-up surveys of the suitable habitat surrounding the site (300 meter radius) should be conducted 1-2 weeks after the initial survey.

If visual or auditory detection of a goshawk is made during a Stand Search, *but no sign is encountered in the stand*, Broadcast Acoustical Surveys of stand and adjacent stands should be conducted.

Primary advantages: This method yields a higher probability of identifying nest stands when goshawks are not currently breeding or have failed, and can detect alternate nest stands where goshawks are not currently breeding. Provided that experienced observers are utilized to conduct surveys, this method may be implemented during 1 year.

Primary disadvantages: Intensive stand searches are labor-intensive, and best suited to assessment of small patches of habitat 10-100 acres in size. Requires a minimum of 3 persons for effective survey. Not likely to detect goshawks nesting over 200m from survey unit. The effectiveness of this method also can vary depending on the time of the breeding period during which it is conducted. In general, the effectiveness of this method increases with time during the breeding season as more sign may be present in occupied nest stands later in the breeding period. However, surveys conducted later in the breeding period may be less effective in territories with early nest failures, particularly in regions where summer monsoonal precipitation can reduce detection of whitewash.

The effectiveness of this method is highly dependent on detection of sign and nest structures, which may be present regardless of current goshawk reproductive status. For this reason, detection of sign or nests triggers an "occupied" status for the stand surveyed and surrounding area.

Additional surveys during 1 or more years may be required to locate the nest site and establish appropriate management zones.

Broadcast Acoustical Survey

This method is based on broadcast of taped goshawk calls at points along transect routes to elicit responses from defensive territorial adult goshawks and their young. Often termed the "Kennedy-Stahlecker Protocol", it is currently the standard method used by the Forest Service and many others. The efficacy of this method has been evaluated in terms of response rates at *known successful nests* (Kennedy and Stahlecker 1993, Joy et al. 1994, Watson et al. 1999), and recently at territories occupied by nonbreeding goshawks (Keane and Woodbridge unpub.).

Adjustments to the number of surveys required and spacing of calling stations were made to optimize probability of detection and survey effort and cost. Based on data presented in Kennedy and Stahlecker (1993), Watson et al. (1999) and Keane and Woodbridge (unpub.) the survey specifications listed below should have approximately at least an 80% detection rate.

1) Establishment of survey transects and stations: Prior to initiating surveys, use aerial photographs and topographic maps to determine optimal placement of survey transects. Draw detailed maps of survey routes and station location and provide them to field crews conducting surveys. When possible, establish start and end points of transects along existing roads, trails, streams or other landforms. The maximum distance between parallel transects should be 250 meters. Minimize number of stations located on roads, unless roads are entirely within habitat of interest. Call stations should be located 200 meters apart along each transect. To increase coverage, offset station locations on adjacent transects by 100 meters. The most important factor in transect and station placement is completeness of coverage; to achieve acceptable confidence in survey results, all suitable habitat should be within 150 meters of a calling station.

For project surveys, the survey area should include the proposed project area plus an additional buffer beyond the project boundary. For projects involving significant modification of forest structure (ex. commercial thinning), survey $\frac{1}{2}$ mile beyond the project boundary. This distance corresponds to the mean radius of the post-fledging area (about 500 acres) and will allow detection of territories that overlap the project area.

For projects that involve minor modification of forest structure (underburning, light underthinning, light salvage) surveys need extend only $\frac{1}{4}$ mile beyond the project boundary.

2) Timing of surveys: Surveys should be conducted during the nestling and fledgling periods, including early post-fledging dependency. In general, this period corresponds to June 1 to August 15 over much of the range of the northern goshawk. When possible, use local information on nestling ages and dates to estimate hatching dates. After August 15, many fledgling goshawks will have moved out of the immediate vicinity of the nest stand, making location of the actual nest more difficult. Survey results may be considered unreliable after August 30. Surveys may begin $\frac{1}{2}$ hour before sunrise and should cease $\frac{1}{2}$ hour before sunset.

3) Calling procedure: At each calling station, broadcast at 60 degrees from the transect line for 10 seconds, then listen and watch for 30 seconds. Repeat this sequence 2 more times, rotating 120 degrees from the last broadcast. Repeat 3-call sequence again. After the last sequence, move to the next station. Move (walk!) between stations at an easy pace, listening and watching carefully for goshawk calls and sign. The majority of time will be spent walking between stations, so it is important to be alert for goshawks approaching, often silently, to investigate the surveyor. Do not survey from vehicles, or use vehicles to move between stations. Use of two observers probably enhances the probability of visual detections of goshawks, however experienced surveyors may conduct surveys singly. To avoid misidentifying broadcasts of co-workers, simultaneous surveys should be conducted no closer than two transect widths apart.

- During the nestling period, broadcast the Adult Alarm call.
- During the late nestling and post-fledging period, broadcast the juvenile begging or wail call. This call is more likely to elicit responses from juvenile goshawks.

Do not survey under conditions such as high winds (>15 mph) or rain that may reduce ability to detect goshawk responses.

Record the detection type, compass bearing, station number and distance from transect of any responses detected. Attempt to locate goshawk visually and determine the sex and age (adult versus juvenile/fledgling) of responding individual.

4) Number of surveys: Surveys should be conducted at least twice during a given year. Detection rates of one, two, and 3-visit surveys are given in table 2. Depending on survey objective, surveys may need to be conducted during 2 consecutive years.

5) Equipment: Effective coverage of a survey area is dependent on the surveyors' ability to broadcast sound that can be detected at least 200 meters from the source. Kennedy and Stahlecker (1993) and Fuller and Mosher (1987) recommend using equipment producing at least 80-110dB output at 1 meter from the source. Regardless of the type of equipment used, broadcast goshawk calls should be audible to at least 200 meters from the calling station. Until recently, the most commonly used broadcast equipment has been a small personal cassette player connected to a small megaphone. Recent developments include CDs and MP3 players as storage media and improved digital amplifiers that store goshawk calls on internal chips. Other equipment required for surveys include compass, binoculars, flagging or other station markers, and ziploc baggies and labels for feathers and prey remains.

6) Preparation for Survey: Study the appearance and typical flight patterns of goshawks and similar species prior to conducting surveys. Recent field guides should be consulted to review the field marks of male, female, and juvenile goshawks, as well those of Cooper's hawks, and red-tailed hawks.

Practice recognizing goshawks under field conditions prior to conducting surveys. Forest-wide and Regional training sessions should include visits to a few known nests to allow survey personnel to develop familiarity with goshawk behavior and vocalizations. Identification of goshawk nests, plucking posts, feathers, whitewash patterns, and typical prey remains are also important aspects of survey preparation.

Learn the typical vocalizations of goshawks and species with similar calls by listening to recorded examples. Examples of high-quality goshawk recordings are available from Cornell Laboratory of Ornithology's *Birds in Forested Landscapes* program, and the Forest Service *Voices of Western Forest Raptors* CD. Field experience is important in learning to distinguish the vocalizations of goshawks from those of mimics such as gray jays and Stellers jays. These species are capable of producing excellent imitations of goshawk calls, particularly the female wail and juvenile begging call, and often respond to broadcast calls. Pileated woodpeckers, northern flickers, sapsuckers and Cooper's hawks also have calls similar to those of goshawks.

7) Interpretation of Goshawk Responses: Surveyors should be aware of different types of responses likely to be encountered during surveys. Joy et al. (1994) classified responses into 3 categories, vocal non-approach, silent approach, and vocal approach. The frequency of each response type varied between sexes, ages, nesting stage, and vocalization broadcasted.

Vocal non-approach – goshawks may respond by perching away from the surveyor, often at the nest, and vocalizing. This response is commonly elicited from older nestlings and juveniles as begging calls, in response to broadcast of either alarm or food-begging calls.

Silent approach – goshawks, particularly adult males, will frequently fly silently in the direction of the surveyor to investigate, and may be visible only briefly. Silent approach by female goshawks during the nestling and early fledgling periods typically indicates an active nest within 200 meters, but male responses may be long distances from the nest. *Failure to detect this common response is a likely cause of poor survey results.*

Vocal approach – commonly in response to broadcast of alarm calls, adult female goshawks (and, less often, males) frequently fly towards the surveyor while vocalizing alarm calls. This response typically indicates the active nest is within 200 meters, particularly if the adult goshawk remains in the vicinity of the surveyor.

8) Locating active nests: Searches for active nests may be conducted immediately following goshawk detections (particularly vocal approaches or attacks), however it is often necessary to review the results from multiple surveys and stations from a larger area to approximate the likely areas to search. Response type, distance and direction from transect, and distribution of habitat should be plotted on aerial photographs, and the Intensive Search Method should be employed.

Primary advantages; This method is a commonly used, standardized protocol with estimates of effectiveness at breeding and nonbreeding sites, and a known rate of effort and cost (Joy et al. 1994, Watson et al. 1999). It is efficient and applicable to large areas of land. In the protocol described here, minor adjustments to the number of surveys required and spacing of calling stations were made to optimize probability of detection and survey effort and cost.

Primary disadvantages; Effectiveness has been studied largely at active nests (Watson et al. 1999, Kimmel and Yahner 1990, Kennedy and Stahlecker 1993). Effectiveness is likely reduced at non-breeding or failed sites (Keane and Woodbridge unpub). Studies of occupancy, breeding and success rates suggest that 20-80% of territories could be missed in a given year due to non-breeding or failed reproductive status if detection rates are low at these sites. A high proportion of responses are from fledglings, which are not present at failed or non-breeding sites. Multiple years of surveys may partially mitigate this factor. Recent work reported by Watson et al. (1999) suggest that increased numbers of surveys/year or closer spacing of sample points (above Kennedy and Stahlecker 1993) may be needed to increase probabilities of detecting active nest sites.

Watson et al. (1999) reported that the probability of detecting an active nest was affected by the distance from the call point and the number of broadcast samples conducted at a call point. They reported single-visit probability of detections of 0.42 at 100m from active nests, 0.25 at 250m, and 0.20 at 400m. Based on cumulative response curves they estimated that single visits to nests had probability of detections of 60% at 100m and 38% at 250m. Kennedy and Stahlecker (1993) reported detection rates of 73% during the nestling period and 77% during the fledgling-dependency period at 100m from active nests based on single visits. Little is known about the probability of detecting non-breeding adult goshawks at inactive territories or territories with failed breeding attempts (see Kimmel and Yahner 1990, Kennedy and Stahlecker 1993,

Watson et al 1999). Keane and Woodbridge (*unpub.*) reported single-visit detection rates of 64% at occupied territories with failed nests or nonbreeding adults (table 2), compared with 90% at sites with active nests. Response rates are lower and more highly variable at territories with failed reproductive attempts, and particularly at territories with non-breeding adults, relative to territories with active and successful nests.

Several issues require further consideration and research. First, further research is needed to evaluate the relationship between detection rates and distances between sample points. Second, given uncertainty regarding the efficacy of this method in detecting non-breeding goshawks or failed nest attempts, multi-year surveys are required to have a high confidence in locating active nests (DeStefano et al. 1994). Third, this method is likely very sensitive to observer bias (observer experience and motivation). Finally, the method is labor intensive and can be difficult to fully implement in steep, rugged terrain.

Table 2. Comparison of detection rates of two survey methods for Northern Goshawks. Data from Keane and Woodbridge (*unpub.*)

Method	Territory plot status		
	Nesting	Occupied Non-nesting	Unoccupied- Old nests ²
Broadcast Acoustical Survey Protocol			
1 visit	0.90	0.64	0.36
2 visits	0.94	0.87	0.59
3 visits ¹	1.00	0.96	0.73
Stand Search Survey Protocol			
1 visit	0.97	0.74	0.43
2 visits	1.00	0.93	0.67
3 visits	1.00	0.98	0.81

¹ 3-visit probability calculated using binomial expansion of 1-visit detection p

² rate is for detection of old nests at unoccupied territory plots

Interpretation of Survey Results: Status Determinations

Application of survey protocols results in detections of goshawks and their sign that must be interpreted and compared with criteria for determining the status of a territory or survey area. Even with clearly-defined criteria, there will always be some ambiguity in status determinations because of the high mobility and secretive nature of nesting goshawks. Positive data such as vocal responses and molted feathers are easily interpreted, whereas negative or scant data are difficult to "prove".

Status determinations are strongly influenced by the intensity and areal extent of survey efforts. Conducting a brief Intensive Search may be adequate to determine lack of occupancy for a 50-acre nest stand, however this determination cannot be extrapolated to the entire territory.

Status determinations are also influenced by the objectives of the survey. For project surveys, lack of detections may mean that goshawks do not inhabit the project area, or that the surveys were conducted within a goshawk home range but not within the defended core area. It is important to establish *a priori* whether surveys are for simple presence or for occupied nest sites within some prescribed area.

The following categories of area or territory status are used to describe outcomes of goshawk surveys, and should be used in effects determinations under NEPA.

a. Presence –

Simple determination of whether goshawks are present or absent in a given area may be adequate for broad-scale monitoring where information on nest site location or reproductive status are not required. Presence in this case is used as a surrogate for occupancy, recognizing that some detections will be of subadult or nonterritorial goshawks ("floaters"). Types of evidence used to determine presence are:

- 1) Goshawks seen or heard in survey area.
- 2) Presence of goshawk molts (feathers) in survey area.

b. Occupancy –

Occupancy is defined by the presence of territorial adult goshawks within a nesting area, regardless of reproductive status. Types of evidence used to determine occupancy are similar to those used for presence/absence, except that more evidence of consistent use is required to determine territorial occupancy (from Reynolds et al. 2002):

- 1) Goshawks seen or heard in survey area.
- 2) Presence of goshawk molts in survey area.
- 3) New construction (greenery) and/or down on nest structure.
- 4) Goshawk feces in or near nest site.
- 5) Presence of prey remains in or near nest area.

Determination of occupancy requires:

Confirmed occupancy -

- 1) Any combination containing 3 of the 5 evidence types located in or near a nest site (Confirmed Occupancy).
- 2) Evidence type 1 on two or more separate visits.
- 3) Combination of evidence types 1 and 2, 1 and 3, or 2 and 3 located/observed in or near nest site.

Possible occupancy – additional surveys required for determination -

- 4) Location/observation of any one evidence type (excluding #4&5).
- 5) Combination of evidence types 4 and 5 only

Assignment of 'non-occupied' status to a survey area is problematic because of the intensive effort required to support this determination. In most cases it is preferable to categorize areas without detections as 'surveyed with no detection'.

Reproductive Status

Active Nest –

An active nest is a nest that has supported a reproductive attempt. Non-reproducing goshawks may reconstruct or add greenery to one or more nests during the courtship period, therefore evidence of egg laying is required to support a determination of active nest.

Direct evidence of egg laying includes:

- 1) Observation of eggs (during climb to nest, from upslope, or with a mirror).
- 2) Observation of nestlings.
- 3) Observation of fledglings in nest tree or nest area.

Indirect evidence of egg laying includes:

- 1) Observation of adult female in incubation posture (sitting low on nest, often barely visible) on two or more separate days.
- 2) Presence of eggshell fragments below nest or near nest tree (fragments may be from failed eggs as well as after hatching).
- 3) Presence of dime-sized nestling mews (feces) below nest tree (typically found when nestlings are greater than 4 days old).

Successful Nest –

Active nests are considered successful if one or more fledglings survive to the branching or fledging stage (>34 days old).

Direct evidence of fledged young includes:

- 1) Observation of one or more young goshawks judged to be at least 34 days old on nest or within nest area.
- 2) Auditory detection of >1 goshawk giving begging calls near nest showing signs of fledging young (copious feces on ground, down on nest) after usual fledging date (early July – August).

Indirect evidence of fledged young includes:

- 1) Observation of active nest with signs of recent fledging (copious feces on ground, down on nest, molted feathers, prey remains).
- 2) Observation of remains of predated fledglings (>34 days old based on length of primary or tail feathers) in nest area.

If nest checks are made while nestlings are <34 days old, the nest may be classified as 'Active with young', but Nest Success remains unknown.

Fledging Rate -

Accurate determination of the number of fledglings produced at goshawks nests is made difficult by the variability in fledging dates and behaviors of male and female fledglings. Male goshawks may leave the nest up to 10 days earlier than females, and fledglings may or may not return to the nest to roost and feed. Recently-fledged goshawks are often lost to

predation, and are likely to be overlooked in fledgling counts. Simple counts of late-stage nestlings (28-34 days) have the potential to miss early-fledging males, or individuals laying down low in the nest cup, especially in larger broods.

If productivity data are desired, it is preferable to use counts of large nestlings (24-30 days old) as a surrogate for actual number fledged. If counts are made from the ground (nest tree not climbed), they should be repeated at least once to increase the probability of detecting all individuals. At nests with limited visibility, such counts are unlikely to consistently provide accurate information.

Survey Protocol Applications

Goshawk survey protocols may be used individually or in combination to address a variety of objectives. It is often desirable to vary the intensity or areal extent of surveys to most efficiently achieve specific objectives, depending on the type of goshawk data required, timing of projects, budgetary constraints, and logistical considerations.

The most common objectives of goshawk surveys are territory monitoring, small-area surveys for forest management projects, and large-area surveys for assessments or broad-scale management projects. The survey protocol applications provided below are designed to increase efficiency by maximizing detection rates and focusing survey effort

Territory Monitoring Application --

This application is for monitoring the presence (occupancy) of goshawks on known territories, determining nest locations, and determining reproductive success and productivity. The application is a stepwise process, based on use of three survey protocols that are described in detail separately. To maximize efficiency, the stepwise procedure focuses more intensive methods, early in the season, on areas most likely to contain the active nest. If goshawks are not detected during the first survey steps, more extensive methods are employed to locate new, widely-spaced alternate nests.

Annual nest-site movements by goshawks are an important and often overlooked aspect of territory monitoring projects. Monitoring efforts focused on one or two known alternate nests are unlikely to accurately determine occupancy and breeding status of entire territories, which often encompass alternate nests scattered over a 2000-acre area. If budgetary or logistical constraint limit survey efforts to a smaller area, the status determination must be made at that scale and not extrapolated to the entire territory.

Protocol --

Preparation: Using recent aerial photographs or Digital Orthophotoquad maps, superimpose a grid (100 x 100m cell size) over the "territory area"; a 1-mile radius surrounding the last known nest or geometric center of all known alternate nests in a territory. In particular, this map should display roads, streams, drainages, and openings that will be helpful for locating plotted nests, areas to be searched, and broadcasting stations in the field.

Level 1 Survey:

Conduct Dawn Acoustical Survey Protocol at points within 200 m of known nest sites, starting with last known nest. If goshawks are detected, **status = occupied**.

Conduct Intensive Search around detection area during incubation or nestling stage to determine breeding status. If goshawks are not detected, go to Level 2 Survey.

AND/OR

Level 1 Survey:

Conduct Intensive Search Protocol of all forested areas within a 100 m radius of all known nests with known territories. Start with last known nest. Survey should be conducted after hatching through 3 weeks post fledging, or about late May through mid-August. Surveys may be conducted earlier (during incubation) but is likely less effective due to lack of sign and lack of defensive behavior by incubating females.

If active (with incubating hawk, or nestlings) goshawk nest is found, **status = breeding. Stop.**

- 1) If goshawks or sign (minimum criteria for sign are molted feathers associated with multiple patches of whitewash and/or a nest showing signs of recent reconstruction), are found, but active nest is NOT found, **status = occupied, To locate active nest, go to Level 2 Survey**
- 2) If initial Intensive Search Protocol was conducted during the incubation period (late April to mid-May), may repeat Level 1 Survey in 2-3 weeks instead of Level 2 Survey.
- 3) If goshawks or sign are NOT found, go to Level 2 Survey.

Level 2 Survey:

Conduct Intensive Search Protocol of all forest habitats within 500 m of last known nest

If active goshawk nest is found, **status = breeding. Stop.**

- 1) If goshawks or sign are found, but active nest is NOT found, **status = occupied.**

Repeat survey in area of detection in 2 weeks. If goshawks or sign are NOT found, go to Level 3 Survey.

Level 3 Survey:

Conduct Broadcast Acoustical Survey Protocol (2 visits) within a 1600 m (1-mile) radius of the last known nest. Delete areas previously searched in Level 1&2 surveys from the Level 3 Survey. This technique is most efficient after the eggs hatch, typically after late May or early June depending on location

If active goshawk nest is found, **status = breeding. Stop.**

If goshawks or sign are found but active nest is NOT found, **status = occupied nonbreeding. Stop.**

If goshawks or sign are NOT found, **status = unoccupied. Stop.**

Rationale

Effort-intensive methods such as Dawn Acoustical Surveys and Intensive Search Surveys have higher detection rates and may be conducted earlier in the breeding season than Broadcast Acoustical Surveys. Early-season surveys are critical for detection of breeding attempts that fail during incubation; before Broadcast Acoustical surveys are typically implemented. If early failures are undetected, territories will incorrectly classified as nonbreeding.

If intensive methods focused in known nest cores and high-priority habitat fail to detect goshawks or sign, more extensive methods must be employed to locate alternate nests, which may be up to 1.2 miles distant from known nest sites. Without these extensive Broadcast Acoustical surveys, determination of status cannot be made for the entire territory.

The Status determinations made within this stepwise approach are not absolute; they have an associated confidence estimate based on field data. Long- term monitoring data from the Kaibab Plateau (Reynolds et al. unpub.) indicate that searching a 550 yd radius around known nests will capture about 62% of the alternate nests within a territory. A radius of one mile yields an 88% likelihood of capturing all alternate nests within a territory.

Small Area Survey Application

Many land management activities occur at scales considerably smaller than goshawk territories or home ranges. Effects analyses for many such projects may only require knowledge of goshawk nest site locations within a limited area (10 to 200 acres). Project surveys typically are employed to address two information needs; location of territory 'cores' for long-term habitat management, and location of currently active nests for mitigation or avoidance of disturbance.

Habitat Management: For projects that involve removal or adverse modification of goshawk nesting habitat, managers are interested in knowing whether the project area contains goshawk nest sites, regardless of whether they are active during the year of project implementation. Survey methods used in this case must be capable of detecting nonbreeding goshawks or sign, and unused nests.

Mitigation of Disturbance: For projects that do not involve significant modification of goshawk habitat, impacts to goshawks may still occur in the form of disturbance of breeding behavior of nesting goshawks. For such projects, managers are often interested in knowing whether goshawks are actually nesting during the year of project implementation, so that seasonal restrictions may be applied to mitigate disturbance. Survey methods used in this case are geared toward efficiently locating currently active nests, as early in the breeding season as possible.

For either survey objective, Dawn Acoustical Surveys provide a very high probability of detecting goshawks regardless of breeding status. If access to the survey area is feasible during early spring, and the patches of suitable habitat to be surveyed are relatively small, Dawn Acoustical Surveys are the preferred method for early detection of occupancy by goshawks. Detections with this method are usually obtained in March and April, and a brief search of the detection area during the late incubation or (preferably) nestling stage is required to determine the location of an active nest.

If early spring access is not feasible, Intensive Searches should be used during the nestling and/or fledging period. Compared with Broadcast Acoustical Surveys, single-visit detection probabilities are higher for this method, as is the likelihood of locating goshawk sign, unused nests or other indications of a territory core (table 2).

Large Area Survey Application

Landscape- level surveys for goshawks may be required for watershed analyses, population research projects, or effects analyses for broad-scale forest management projects. In most cases, information is available to allow managers to focus intensive surveys early in areas most likely to be occupied by goshawks, reducing the need for more extensive

methods later in the breeding season. This application provides a step-down survey plan to 1) reduce the area requiring physical surveys, and 2) maximize efficiency in surveying specific habitats.

Use data from known goshawk territories in your area (same bioregion, forest type) to create a descriptive model of suitable (likely to be occupied) habitat versus low-quality habitat. Model parameters should include forest structure (species composition, size class, density) as well as patch size, topographic features (slope, aspect), and hydrologic features (meadows, riparian habitats) that are often associated with goshawk nest areas. In a GIS, use this model to 'classify' a vegetation data layer into high priority survey areas (suitable nesting habitat) and low-priority survey areas.

Plot locations of previously known goshawk territory centers (or last known nests) onto the habitat map and create a buffer of 1-mile radius around each point. The area requiring surveys can be reduced by deleting these buffers from the survey area. This radius is likely to contain the current nest site AND unlikely to contain an additional territory.

After removing known territory buffers from the survey area, develop a step-down survey plan for the remaining area. Selection of survey protocols and the timing of survey efforts should be based on the amount, distribution and patch size of suitable nesting habitat, and feasibility of early spring access.

Step 1: If early spring access is feasible, use Dawn Acoustical Surveys at patches of high-priority habitat, patches with past goshawk sightings and historic nest areas. This allows early deletion of newly discovered occupied areas from survey area, and allows early inclusion of goshawk management into project planning. If Dawn Acoustical Surveys are not feasible, use Intensive Searches as early as possible in high-priority patches.

Step 2: Conduct Intensive Searches in all high-priority habitat patches during the nestling period (May-June). Start with habitat patches located 1.5 to 3 miles from currently known territory centers. If detections are not obtained in areas of high-priority habitat, repeat Intensive Search at in least 2 weeks, or incorporate into broader Broadcast Acoustical Survey in Step 3.

Step 3: If large areas of suitable habitat remain to be surveyed, establish transects for Broadcast Acoustical Surveys to cover entire area. Surveys should be conducted twice, once during the nestling period and again during the fledging period.

Quality Control/Quality Assurance

Protocols for goshawk surveys are well established, and standardized surveys have been conducted on this species for over 12 years (Kennedy and Stahlecker 1993, Joy et al. 1993, Woodbridge and Keane 2000).

No evaluations of the potential bias introduced from observer variation on northern goshawk survey methods and results have been conducted. Observer variation has been demonstrated to affect the effectiveness of wildlife surveys (Verner 1985, Verner and Milne 1989). Experience and motivational levels of observers conducting the fieldwork likely have significant effects on the efficacy of northern goshawks surveys. Often surveys are conducted by seasonal technicians with no or very limited experience with northern goshawk behavior, identification, and survey methodologies. Anecdotal observations on many occasions in a California study indicated that inexperienced crews using broadcast surveys did not locate active nests that were subsequently found by experienced observers using broadcast surveys and stand searches (Keane and Woodbridge *unpub.*).

Keane and Woodbridge (*unpub.*) compared detection rates of experienced and inexperienced teams conducting broadcast acoustical and intensive search survey protocols. Detection rates of inexperienced observers in this study were initially lower than those of experienced observers, but rapidly improved to roughly the same levels by early July. It is likely that early season training and exposure to goshawks in the field have a strong influence on the extent of observer variation in goshawk surveys. Research is needed to develop an understanding of the magnitude of observer bias on survey efforts and each of the specific survey methods.

Standardized training materials should be developed and provided to field personnel planning to conduct goshawk surveys. Training materials should include identification of vocalizations of goshawks and sound-alikes, identification of goshawks and other forest raptors, identification of molted feathers of forest raptors, and detailed description of survey protocol implementation. Two training products; *Voices of Western Forest Raptors and sound-alikes* and *Feather Scans of Western Forest Raptors* are available through the Forest Service for training and field survey use. Training sessions should be conducted in association with goshawk study sites where trainees can observe nesting goshawks.

Annual field crews should consist of 2-person teams (1-experienced GS-7 or equivalent, and 1- technician GS-04 or equivalent on each team). Each field crew should have at least one member who has field experience with goshawks and knowledge of goshawk vocalizations, sign, and behavior and who can serve to train inexperienced partners. At the completion of each survey visit, data entry forms and maps should be assembled and reviewed for inconsistencies or incomplete data by the survey crew leader.

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